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THE CATACOMBS OF ROME.

THE Roman catacombs consist of a vast labyrinth of galleries excavated in the bowels of the earth in the hills around the Eternal City—not in the hills upon which the city is built, but in those beyond the walls. Their extent is enormous, not as to the amount of superficial soil that they underlie so much as in the actual length of their galleries; for these are often excavated on various levels, three, four or even five, one above the other, and they cross and recross one another, often at short intervals, on each of these levels, so that the whole soil is honeycombed by them; and it has been calculated that if stretched out in one continuous line they would extend more than 350 miles, *i. e.*, more than the whole length of Italy itself.

Each cemetery was originally of very limited extent; and though some were joined together at later periods, still a deep valley was always sufficient to keep apart the systems of excavation even of two adjacent hills, the Via Ardeatina, was known by the name of St. Mark, the pope who founded it. Others, again, received the names of the principal martyrs who were buried in them.

Modern research has placed it beyond a doubt that these excavations were used exclusively by the Christians as places of burial and of holding religious assemblies, and that they were not deserted sand pits or quarries adapted to Christian uses, as has been supposed. The men who dug the catacombs were called *fossores*, and theirs was a work that required not only a certain amount of skill and labor, but also zeal and devotedness to the Christian cause.

There is something more than mere galleries of graves in the catacombs. At various intervals the succession of shelves is interrupted, that room may be made for a doorway, which admits us into a chamber, or perhaps a succession of chambers, which are generally small and of rectangular form. Some, however, are of considerable size, and hexagonal, polygonal, or even circular in shape. If the walls of these chambers are only pierced with graves, we conclude that they were mere family vaults, and here and there an inscription has been preserved which tells us to what family this or that chamber belonged. Sometimes a low bench may be seen cut out of the rock all around the chamber and a chair of the same material on one or both sides of the entrance. This would seem to indicate that the chambers had been designed as places of assembly for the purposes of instruction or for prayer and psalm singing. Sometimes the wall opposite the doorway, or even on all three sides of the chamber, is pierced, not with graves like those of the galleries, but for a tomb of a more elaborate and costly kind.

At first the making of the catacombs was done openly, the Christian graves being as effectually protected by law as were those of the pagans. During this time, the entrances to them were made public on the highroad or on the hillside, and the galleries and chambers were decorated with paintings of a sacred character. But in consequence of imperial edicts of persecution at certain periods during the third century, it became necessary to withdraw them as much as possible from the public eye, and to this effect new and difficult entrances were made in the recesses of deserted sandpits. Sometimes the emperors contented themselves with forbidding the holding of assemblies in the cemeteries; sometimes they even confiscated the cemeteries themselves, so as to interfere with the freedom of burial in them. In spite of every difficulty, however, the Christians persevered in the use of them, as far as they could, for both purposes, and they continued to do so at the cost of their lives, down to the very end of the period of persecution. After the fatal year 410, when Rome was taken by Alaric, the use of the catacombs as the ordinary Christian cemeteries of Rome altogether ceased.

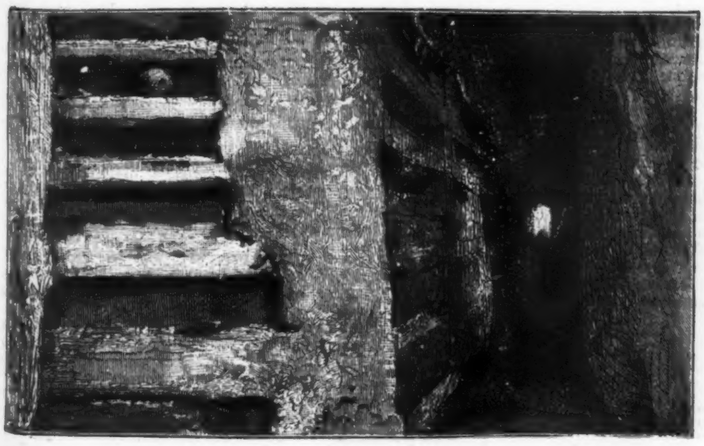
By this time, however, they had gradually assumed another and more important character, having become an object of enthusiastic devotion. The crowds that visited the tombs of the martyrs on the annual recurrence of their respective festivals were immense, so that it became necessary to provide more commodious means of entrance and exit, and in other ways to enlarge and improve the chapels within.

The festivals continued to be celebrated here as long as the bodies of the martyrs remained in their original resting places. But these having been desecrated and sometimes plundered by the Lombards and other invaders of Rome, the principal relics were removed into the city churches by the care of successive popes, during a period of sixty or seventy years, and when this had been done, the catacombs were gradually neglected, and by degrees forgotten.

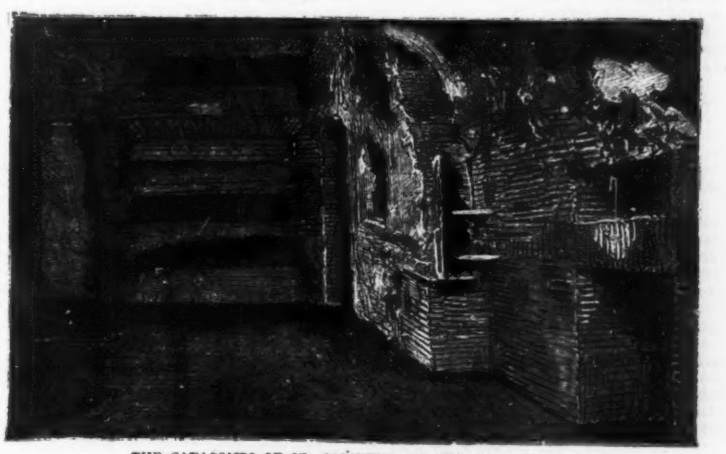
We present herewith some reproductions of a few instantaneous photographs taken through the aid of the magnesium light, and showing the chapels of various early Christian martyrs.

CATACOMBS OF ST. SEBASTIANO

THE CHAPEL OF MARLIRI MAXIMO



CATACOMBS OF ST. AGNES



THE CATACOMBS OF ST. CALIXTUS, CHAPEL OF ST. CECILIA

THE CATACOMBS AT ROME. FROM INSTANTANEOUS PHOTOGRAPHS TAKEN BY THE MAGNESIUM LIGHT

for the lowest or connecting galleries would soon have become subterranean canals.

The subterranean galleries are narrow, ranging from two to four feet, and they vary in height according to the nature of the rock in which they are dug, but rarely exceed eight or ten feet. The walls on both sides contain horizontal niches—flat, oblong compartments like shelves in a book case or berths in a steamer. Every niche was made to contain one or more bodies.

These vast excavations once formed the ancient Christian cemeteries of Rome. They were begun in apostolic times, and continued to be used as burial places of the faithful till peace was given to the church; and even after this time, though the practice of burying *sub dio* then became more common, the catacombs were still used for the same purpose, in some degree, till the capture of the city by Alaric in the year 410, but not later. In the third century, the Roman Church numbered 25 or 26 of them, corresponding to the number of her parishes within the city; and, besides these, we know of about twenty others, of smaller dimensions, which may have existed at the same time, perhaps, but were the private property of this or that family. At the end of the second century, some of the cemeteries became the legal property of the church, and were administered by the chief deacon under the authority of the bishop. We have direct evidence of this with reference to the catacomb of St. Callixtus on the Via Appia. Another cemetery, on

DIAMOND-BEARING METEORITES.

AN interesting paper on diamond-bearing meteorites was read at the Washington meeting of the American Association for the Advancement of Science, by Prof. A. E. Foote, of Philadelphia. The author describes the meteoric iron found near Cañon Diablo, Arizona, fragments of which contained diamonds. Crater Mountain, 185 miles north of Tucson, is a peculiar circular elevation, strikingly like the crater of an extinct volcano It rises 432 ft. above the surrounding plain, and its cavity is ¾ mile in diameter. Its interior walls are so steep that animals once entrapped within them never escape, but leave their bleached bones at the bottom. The rim of sandstones and limestones is uniformly uplifted on all sides at an angle of 40°, while the bottom lies at a depth of from 50 ft. to 100 ft. below the general level of the plain.

Although the cavity is crateriform, no lava, obsidian,

or other volcanic product was found. Small meteoric fragments were scattered over an area about a third of a mile in length and 120 ft. wide, extending northwest and southeast. Exactly parallel with it, but about two miles from the base of the crater, were found two large masses, one weighing 154 lb. and the other 201 lb. Both were deeply pitted and the larger one was perforated in three places. The latter is now the property of the *Ecole des Mines*, Paris. Smaller masses were also found, numbering 131 in all, ranging in weight from $\frac{1}{16}$ oz. to 6 lb. 10 oz. Several of them were coated with aragonite. About 200 lb. of angular sulphureted fragments, also of meteoric origin, were found near the base of the crater, a few of which showed a greenish stain resulting from oxidized nickel.

A fragment of a mass weighing 40 lb. was examined by Prof. G. A. Köring, who found it to be extremely hard, a day and a half being taken in making a section, and several chisels were broken in the operation. An emery wheel was ruined in trying to polish it. This led to closer inspection of certain exposed cavities, when small black diamonds were found which cut polished corundum as easily as a knife separates gypsum. These diamonds are mineralogically of great interest, their presence in meteorites having been unknown until the year 1887, when two Russian mineralogists found traces of diamonds in a meteorite mixture of olivine and bronzite. By treating the amorphous carbon in the cavities with acid, a small white diamond, $\frac{1}{50}$ in. in diameter, was found, as well as troilite and daubreelite. The general mass contained 3% of nickel. The Widmanstattian figures were not regular. The indications are that a large meteorite, weighing about 600 lb., had become oxidized in passing through the air, and had burst before reaching the earth. It is scarcely credible that the crater could be accounted for by meteoric impact, and its origin is a problem unsolved. The fact of special interest may be accepted as proved that diamonds have been found in meteoric fragments. The specimens were carefully examined by the geologists present at the reading of Professor Foote's paper, and while there were many opinions expressed as to the so-called crater, and as to its relation to the meteor, none doubted the genuineness of the diamonds.

PRACTICAL TESTS OF COMPOUND LOCOMOTIVES.

By C. H. HUDSON, Member Western Society of Engineers.

CONSIDERABLE attention has been paid during the last few years to the use of steam more expansively in our locomotives, and in view of the triple and quadruple expansion in marine service it would seem not unreasonable that we should in some way be able to compound them.

This has been done in a variety of ways and many tests have been made of each type, and some good results, as far as economy in fuel is concerned, have been reported. As a rule, these tests have been for short or single runs, where the coal has been weighed and the water measured, but quite frequently other conditions have been neglected and the engines have been so different that no comparisons could be of value in fixing the rate of economy, though they may and do doubtless point out the fact that there are savings.

As an instance, I recall a test where a new (or rebuilt) compound was tried against an old engine of *about* the same size. The result showed over 20 per cent. saving in *fuel* and almost nothing in *water*. Were we to analyze the conditions, we undoubtedly would have found in the compound clean flues and a clean fire box, while in the other more or less scale on both. Usually a skilled man will have charge of the engine we expect to make the good showing, and thus we get results from that which are not normal and cannot be reached in everyday work. How the working parts compare is not known, but there may have been some difference there.

It is not to be presumed that there will be any intention of making wrong comparisons, but they simply follow an over-anxiety to show remarkably good work from the engine tested. The liability to these errors must be reduced to a minimum to make our tests of full value. We must have a simple engine of an economical character, for a comparison with a poor steamer, or one that did not do its work economically, would be of no value. All conditions should be alike, save the compounding, and then the engines should be manned alike and have the same character of fuel, substantially the same loads, weather, etc. Further than that, the trial should be of sufficient length to carry it down to every day work, and should cover the changing of engineers and firemen, as well as all the vicissitudes of weather and work. In no other way can we answer the criticisms or overcome the skepticism of many regarding the value of the compounding principle. We must be able to show that we not only do save fuel, but that we do not have excessive repairs arising from the changes in machinery.

It is of a trial of this character that I write, the compound engines being of the two-cylinder type. This paper is intended simply to show what *these particular engines did*, and not to demonstrate that other engines or types would or would not do just as well.

The writer was able to cause this test from the fact that in ordering a lot of engines he had one 10-wheeled passenger out of three built on the same specifications compounded, and two consolidation freight engines out of eighteen, on the same specifications, compounded.

The engines were all built by the Schenectady Locomotive Works, and the compounding valves were of the Pitkin design.

The weight of all these engines was the same, 126,000 lb., without the tender, and they were delivered and put into service about the same time.

The simple consolidation engines were 20 × 24 in. cylinders, while the compounds were 20½ and 29 × 24 in. The cylinders of the 10-wheeled simple engines were 19 × 24 in., while those of the compound were 19 and 27 × 24 inch.

The consolidations were substantially duplicates of a large number of other engines of the same character which after some years' use had been worked up to a very economical point.

During the previous year we had procured a 10-wheeled passenger engine, which had been changed experimentally until it had become unusually economical in fuel. This was the basis of the three new 10-wheeled engines, and they were found most excellent in their workings.

The 10-wheeled engines were put in service September 1, 1890, and run upon the eastern end of the East Tennessee, Virginia & Georgia Railway, upon a run of 131 miles and over grades nominally 69 ft. maximum and very long (some of them actually 77 ft.), with 45 per cent. of the line curved, from three to eight degree curves, and not equated. Thus we had grades and curves combined equal to about 85 ft. tangent grades.

There were three regular trains *each way*. Two of them each way, or four trains, weighed an average of 440,000 lb. and occasionally running up to 530,000, and ran at a speed ranging from 32 to 38 miles per hour. The other two were usually of 155,000 lb. weight, but occasionally ran up to 250,000, and ran at a speed of 27 miles per hour. All made part of the stops and some made all.

The 10-wheeled passenger engines were put on these runs, following each other around, four being in the runs a part of the time, and three a part of it. In this way they all got the heavy fast trains at times, and all got the light ones. This service has been kept up until the present time.

The work done from September 1, 1890, to June 30, 1891, a period of ten months, is taken as a test of the engines, and a measure of the value of the principle of compounding.

The two consolidation compounds were placed on the same division, and for six months ran the road with many other engines, but especially with four new simple engines of the same age, build, specifications, etc., following each other around and changing men about the same time.

They were then placed upon the western division of the road, where the grades are lower, being 60 ft. maximum, and with somewhat less curvature, but not equated. As in the other case, four engines of the same age, build, and size, specifications, etc., were compared with our compounds, running the road with them and changing engineers and firemen the same.

These tests for ten months with the passenger engine and eleven months with the freight should certainly show the every-day work of the engines.

Several short tests were made by Mr. Angus Sinclair. The coal was carefully weighed, water measured, indicator diagrams taken and the vacuum in smoke box measured, etc.

The statement below is taken from his report:

Distance from Knoxville to Coal Creek and return.......................62 miles
Grades.......................70 to 90 feet

	Simple. Load in lb.	Compound. Load in lb.
Knoxville to Coal Creek..	689,100	734,050
Coal Creek to Knoxville..	1,313,050	1,290,450
Total..............	2,002,150	2,024,500
Coal used..............	7,040 lb.	5,073 lb.
Saving of coal....... ..		1,967 lb.
Per cent		28 pr. ct.
Water used	49,788 gals.	41,058 gals.
Saving of water....... ...		8,730 "
Per cent......		18 per ct.

Mr. Sinclair says [*National Car and Locomotive Builder*, November, 1890]:

"The methods of measuring coal and water were not satisfactory, the latter being particularly open to error, owing to the curves and grades at the points where measurements are necessarily made. . . . The simple engines labored under two disadvantages during the return trip not experienced by the compound. A car in a preceding train had dropped grease on the rail which caused considerable slipping and sanding of rail during the ascent of a four mile grade, and the train was held twice for orders. . . . On the other hand, the compound doubled one hill, her return train seeming to pull harder than the train of simple engine, notwithstanding that it was eleven tons lighter."

Other trials were made, one of which is shown below, being a trip from Knoxville to Bristol, 131 miles, and return, with a simple and a compound engine under substantially the same conditions as to weather, time on trip, etc.:

	Simple. Lb.	Compound. Lb.
Weight of train, Knoxville to Bristol	1,290,710	1,377,550
Weight of train, Bristol to Knoxville.......	1,228,020	1,196,000
Total....	2,418,730	2,573,550
Excess of work done........................		154,820
Per cent........................		6·4 p. ct.
	Lb.	Lb.
Coal consumed........................	29,728	23,080
Saving in coal........................		6,648
Per cent........................		22·4 p. ct.
	Gals.	Gals.
Water consumed..........	24,535	19,200
Saving in water.....		5,335
Per cent...........		21·8 p. ct.

But the compound did 6 per cent. more work, which would add to the percentage and make the saving shown about 26 per cent.

These results were in the same line as the others, but still the tests are open to errors, as in the other case.

The comparisons of the 10 months' work of the passenger engines are shown in the following tables:

Comparison of Passenger Engines.

	Miles run.	Car miles.	Av. cars pr. ton.	Lb. coal consum'd.	Lb. coal pr.cr.mile
2 Simple engines........	107,885	564,905	5·23	6,263,654	11,086
1 Compound engine.....	48,100	254,204	5·17	2,097,911	8,252

Saving 2·834 pounds of coal per car mile, or 25·56 per cent.

The work of 4 simple and 2 compound freight engines for eleven months is shown as follows:

Simple Engines.

	Miles run.	Car miles.	Av. cars pr. ton.	Lb. coal consum'd.	Lb.coal pr. cr. mile.
4 engines, East End,6 mo..	81,226	1,335,045	16·43	8,252,533	6·132
4 engines,West End, 5 mo..	61,318	1,190,786	19·41	5,977,917	5·029
Total.........11	142,544	2,525,831	17·23	14,230,450	5·634

Compound Engines.

	Miles run.	Car miles.	Av. cars pr. train.	Lb. coal consum'd.	Lb. coal pr. cr. mile.
2 engines, East End, 6 mo..	27,682	495,050	17·88	2,454,142	4·967
2 engines,West End,5 mo..	31,550	712,291	22·57	2,667,505	3·746
Total.... 11	59,232	1,207,341	20·38	5,121,647	4·242

Saving 1·392 pounds of coal per car mile, or 24·70 per cent.

Here we have a marked saving in a year's work. We believe the conditions were such that the test is of much more value than were the first ones made, as they show the every-day work of the compound engines compared with exactly the same simple engine under the usual working conditions. No tests can be fairer, and I have seen none of more value.

I regret to state it, yet it is true, that there was at the start a universal prejudice against the compound among the engineers and firemen. They were pronounced failures before they were set up, and long after they had shown their good qualities the unfavorable criticism continued. They "would not start the train," but they did it. They "could not run up the long hills," but somehow they did it quite as easily as the other engines. They "could not pull within 2 or 3 cars of the other engines," but a year's work shows they averaged larger trains, and in repeated cases they have pulled as heavy trains as any engines on the road.

But when they saw the compound passenger engine run the round trip with a tender of coal, and run easily a hundred miles with one tank of water, they had to admit that there was some good in the new departure.

It is our belief that this test of nearly a year in every-day work, with changing engineers and firemen, against exactly similar simple engines, doing the same work at the same time, is more valuable than any tests yet reported in this country, and demonstrates beyond a question the value of the compound principle in locomotive engines, in the matter of coal consumption.

The importance of this is seen when it is known that the cost of fuel is about 10 per cent. of the whole cost of operating, and when we consider that the 32,000 locomotives in this country probably consume 30,000,000 tons of coal per annum.

There is, however, another matter to be considered, and it is one that has rendered American engineers skeptical as to the real value of the compound engine. That is one of repairs, as well as first cost.

It stands to reason that the cost of maintaining three cylinders or four cylinders will be larger than the cost of maintaining two. To what extent this excess will be found it is not known.

During the first four months of our use of the compound engines we made quite a number of changes, hoping to improve them. This was not necessary to keep them running, and should not be construed as running repairs in any comparison with other engines.

The intercepting valves were changed in various ways and the cylinders bored out, upon the consolidations, from 20 to 20½, giving the power which Mr. Sinclair mentioned as being deficient, as compared with the simple engines. This work was all done by December, and in order to ascertain how the running repairs of the compounds compared with those of the simple engines, I have a report of the repairs upon the engines under consideration from January 1 to June 30, 1891, a period of six months, while they were running together, and for six months of the time in which the consumption of coal is considered. Considering first the freight service, we find that the

4 simple engines in 6 months ran...76,827 miles
Total cost of running repairs done. $1,312 66
Cost per mile run.................. 1·70c.

In the same time and over the same ground, the

Two compound engines ran....... 39,268 miles
And the running repairs cost....... $612 72
Or per mile.... .... 1·55c.

Showing that for this six months the compounds ran more economically than the simple, as far as repairs are concerned.

It is quite probable, however, that in another six months this would be evened up and the cost per mile would have likely been equal to that of the simple engines.

It should be borne in mind, however, that the compound engines did more work; that is, hauled more cars.

The simple hauled........ ...1,456,978 car miles
Or per train..........................19 cars
While the compound hauled. .835,830 car miles
Or per train . ...21·3 cars

During the same six months the

2 simple passenger engines ran.....69,220 miles
Cost of repairs........................$1,213 12
Or per mile run.......................1·75c.
While the compound passenger engine ran . ...29,864 miles
Cost of running repairs..................$527 51
Or per mile run......... .... 1·77c.

Substantially the same as the simple.

The work done by the compound (average cars per train) was slightly less than with the simple engines, but not enough to make any perceptible difference.

These figures of course do not include any general overhauling, as the engines were all new, but did cover the every-day work needed to keep our engines up to the standard.

How much the general overhauling may be affected by the compounding cannot be determined by so short a trial. I see no reason, however, why it should add materially to it. It is true our pressure is a little higher, but we use less coal, and we have not been able to discover thus far any different effect upon the fire box than that upon the simple engines.

When we consider that with cheap coal (say $1.50 per ton) the cost per engine mile for fuel is for freight trains about 7c. per mile, and for passenger 4½c., we can see that a saving of even 20 per cent. in fuel means over a cent a mile, and that it cannot be outweighed by any reasonable, or I may say possible, increase of repairs, as but a small part of such repairs pertain to or are affected by the parts compounded.

We believe this to have been a good practical test of the two-cylinder type of compound engines, and while

no claim is laid to perfection, it seems to have covered a sufficient length of time, amount of work and variety of climatic and other conditions to have overcome the influence of any prejudices, or efforts for or against any particular engine or of any special skill, on the part of any one man that in a short run or experiment might have a marked effect.

It seems safe to conclude that the compound principle as developed in these engines is a valuable improvement upon the simple engines, and that its increased economy in fuel is of sufficient magnitude to more than overcome any possible increased repairs.—*Jour. Asso. Eng. Socs.*

SECTIONS AND MECHANICAL CONDITIONS OF CAR WHEELS.*

By P. H. GRIFFIN.

As 90 per cent. of the equipment of the country has chilled car wheels under it, the subject is determined mainly by wheels of that class. The matter will be presented under two heads:

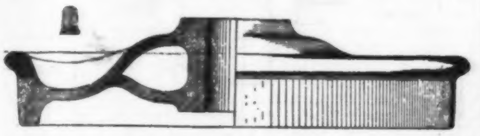
First. Proper section and methods of manufacture.

Second. Mechanical defects, their causes and results.

The strains imposed on a wheel are of two kinds; the first consequent on load carried and speed attained; the second that which results from the use of brakes.

The first strain multiplies the second in a definite degree. Given a speed of 20 miles per hour with a load of 5 tons per wheel, and a pressure of 50 pounds in a 10 in. Westinghouse cylinder giving 10,000 pounds pressure on each brake shoe. One-half of this pressure applied for five minutes under the conditions named will develop through friction a certain amount of heat; the wheel must take up the heat and consequently expand. Just what strain is developed in the wheel during the operation is not easily determined, but it is over 100 tons. You will be able to compute the increase in strain at higher speeds and with greater loads or longer application. As to extreme limits, they must be considered. On heavy grades it is common practice to carry double the load named, at double the speed and with double the continuous brake application; presumably each condition would double the strain. The last one, *i. e.*, heat developed by friction, would increase it in a grater ratio, because it would be a continually increasing condition. It is not only necessary to consider in connection with this matter the speed proposed for general use or the loads intended to be carried, but it is absolutely necessary to consider the maximum that could possibly be imposed, and to provide a margin of safety beyond that.

The accompanying cut illustrates the New York Car



Wheel Works' standard section of 33 in. 600 pound car wheel. As this style of section is followed in different weights and thickness of metal in all diameters, the explanation will apply to them all. It is, as you see, the regular double plate style of wheel known as the "Washburn" pattern. The section lines and curves, however, are peculiar to the standard named, and are based upon many years of practical and extended experience, as well as upon long-continued and elaborate investigations into every feature composing the whole. A 33 in. wheel of this section with ⅝ in. plates and of standard hub, bracket and tread dimensions, weighs 550 pounds, and is the minimum in this diameter for steam railroad service consistent with safety. Wheels are made to this standard in all diameters from 24 to 43 in., and weighing 400 to 1,200 pounds.

In the figure shown the hub section is calculated to stand a strain of 150 tons in pressing on the axle; this is more than double the pressure used. Wheels of heavier section are made, to higher standards in this respect, the limit going up to 500 tons. The core dividing the double plate is made, as you will note, with a slight lip on the outer edge. It is common practice to bring the lines of the core at this point to an abrupt finish, with the idea of making the metal at the junction of the plates heavier, and therefore presumably stronger. As a matter of fact, the opposite result is produced when this is done, for the greater body of metal remains fluid and soft a little longer at that point, and therefore the shrinkage of surrounding parts is fed from it, leaving the metal porous and weak at the very place where it should have the most strength. To this cause is largely due the fine cracks found at the junction of the plates when wheels are subjected to continuous heat service. These cracks do not always go through the plates, often do not penetrate over ⅛ of an inch, but they form starting points for more serious defects.

The core dividing the two plates is known as a "pan core," because it is made in a dish or core pan formed to the shape of the bottom of the core; the top is made with an iron sweep pivoted on a center hub in the core pan. A ring is set in the core pan if a larger hub is needed to give extra metal when a larger sized bore is wanted in the wheel. The use of these rings is very necessary; otherwise wheels are bored out for large axles, with the consequence of leaving insufficient metal in the hub to withstand the strain. There should never be less than ⅞ of an inch of metal in the wheel hub at the center of wheel seat—the thinnest point, after it is bored for the axle.

A depression in the top of the core is made to receive the end of the chaplet which keeps the core in position. Cores are frequently used without this last provision, but it is very necessary, as it provides an extra quantity of metal in the form of a boss on the inside plate of the wheel, at a point where the iron chaplet is very liable to cool the hot metal quickly, and chill it for a space of ⅛ an inch or more around the chaplet, thus providing a starting point for defects. Where the core leg leaves a hole in the bottom plate, the latter is reinforced by a fillet. This is very advantageous, for the same reason as that given in the case of chaplets. A good deal depends on the use of perfect pan cores and upon the exercise of great care in every detail concerning them. When the best attention is not given, internal defects result in the wheel, very difficult to detect. If the chaplets are not exactly and firmly adjusted, one plate will be thinner than the other, and the metal consequently harder and weaker.

The bracket is 1⅛ in. thick at center and 2 in. deep. It fulfills two functions; the first to act as a runner or gate for the molten metal flowing into the tread, and the second to afford strength and support to the tread and flange in service. The section should therefore be determined by the area necessary to admit of the hot metal passing freely and rapidly to the flange and tread, and also by the dimensions best calculated to meet the expansion and contraction resulting from brake service. The bracket is curved to the radius of 5¾ in. inside and 6⅜ in. outside. This is a very important feature. As the hot metal is poured into the mould, brackets of this shape allow it to pass to the tread of the wheel with the least possible strain upon the casting, at a time when it has little or no practical consistency. It is vitally important that the metal be poured into the mould quickly, as hot and fluid as possible; this because of better homogeneity and soundness in the casting.

In regular practice the metal should be cast into a 600 pound wheel in twelve seconds. As it takes, with runners, head, screws, etc., over 650 pounds of metal to cast a wheel of this weight, you can judge the effect of practically dumping almost instantly nearly one-third of a ton of molten metal into a sand mould. Things have to be pretty nicely and perfectly adjusted to admit of that, and the circular bracket is one of the most important features in making it possible. The style of bracket generally in use is the ogee or double curve. Presumably this style gives a better support to the tread, running at right angles to it. In practice, however, it is objectionable, for two reasons.

1. In casting the wheel, the metal forming the tread flows through the brackets and strikes the cold chill forming the tread surface. It is thrown against the chill at a right angle, and must separate and pass to the right and left with many particles partially chilled or frozen, and with no chance for them to remelt and become homogeneous with the balance of the casting. It is almost impossible to pour metal as rapidly through brackets of this kind as through the single curved ones, because of the strain upon the casting when the mould is filling, or to pour as hot metal, for the same reason. With the single curved bracket the pressure on the mould is not direct on its exterior; it is lateral all around.

2. In after service, when the brakes are applied and the wheel expanded, the single curved bracket will adjust itself to the expansion and contraction better than the double curved bracket, and, consequently, prevent what is known as "cracked brackets."

The tread section shown has been considered by some too light. This is probably because of comparison with other patterns having heavy section at this point, to give an apparent solidity to the wheel. The uniform distribution of metal in the wheel is all-important, and no greater mistake can be made than to add to parts which can be judged as to thickness and weight, at the sacrifice of parts the section of which cannot readily be ascertained. It is all-important that the part of the wheel directly under the action of the brake shoe be not of extra thickness at the sacrifice of metal in the plates and brackets. All the strain is thrown on the latter, and the greater the bulk of metal heated in the tread, the more liable the wheel is to crack and break. Due consideration should be given these facts, and proportions followed that will provide against danger from every source.

The point of junction of single plate to tread is very important, chiefly on account of the effect of expansion from brake service. The contact of the brake shoe is necessarily with the flat surface of the tread, and the metal in the flange acts as a preventive against expansion. When the single plate joins the tread too near the top of the latter, it forms, in connection with the flange and brackets, a complete resistance to the expansion of the wheel. If it is kept lower down, when the tread is heated the top portion can expand and the whole casting can, if properly constructed, give a little without fracture; but when, as is sometimes done, the single plate is brought up near the top of the tread, there is, as stated, complete resistance at every point. That is not the way to prevent breakage. The old adage of the "bough that will bend," etc., applies here with force. The single plate is sometimes brought near the top of the tread to prevent the latter "chipping" or breaking out; but trouble of this kind does not occur if wheels are properly and carefully made, and the practice is dangerous, for the reasons stated. Any style of chilled wheel can be tested for capacity to stand expansion from brake service by the following simple means: Lay it horizontally on the foundry floor; provide a sectional pattern that will allow sand to be moulded around the wheel and leave an opening ½ in. wide all around extending from the throat to the edge of the tread. This may be quickly filled with molten iron from several small ladles, and the result is a band of hot metal ½ in. thick and 4 in. wide, cast around the wheel. The effect is the same as that produced by a sudden and severe application of brakes. If properly constructed, the wheel should not crack in the plates with the application of the test. It causes a series of fine vertical cracks around the wheel and renders it unfit for service, but it may be used with entire satisfaction as to the value of results on wheels condemned for slight foundry defects. So much for the general details of construction.

The mould having been prepared, however, presumably in a proper manner, the quality of metal poured into it determines vitally the character of the wheel. On the preparation of the metal a few words may be said. The cupola is prepared and charged. If the metal is of good quality and strength and is properly poured into the mould, all is well so far. But the most exacting attention to every detail is necessary in preparing and melting the iron. If not given, it may not always produce dangerous conditions, but it will not produce perfect ones. A chill test block 2 in. square by 6 in. long cast from the metal should have a chilled surface at least ⅞ in. deep; this degree of hardness on the test will give ½ to ⅝ in. chilled surface on the wheels. A test bar 1 in. square by 12 in. long cast from the mixture should not break at less than 2,500 lb. when supported at the ends and loaded at the center; it should carry a load up to 3,000 lb.

It is the practice of some wheel makers to establish their results in this way by deductions from bars of different sections and length, but on account of the decrease in strength due to the extra hardness of small sections, deductions obtained in this way are unreliable. It is also stated by some that proper strength cannot be obtained in a bar of 1 in. section on account of hardness of metal. This is an excellent proof of the value of the 1 in. section when it is considered that the greater part of a wheel is less than 1 in. thick. Any wheel maker who cannot furnish test bars from his mixture, 1 in. sq., that will carry 2,500 lb. load between supporters 12 in. apart, is not using a mixture that is what it should be; and if such bars will not carry 2,000 lb., the wheels are positively dangerous for use.

After the wheel is cast it is placed in the annealing pit. Properly speaking, car wheels are not annealed; they are slowly cooled, for the reason that in the process of manufacture the outer part of the tread is cooled and set at a degree of heat lower than that existing in the body of the casting (this on account of the chilling process), and the entire casting must again be brought to a uniform heat and cooled evenly. The cooling pits, as they may be properly called, should be in dry ground. If dampness is found and steam is seen arising from the pits while the wheels are cooling or when they are being removed, shrinkage strains will certainly be found in the wheels and they will be liable to break in service. When such conditions exist they are always indicated by a reddish color on the wheels when cold.

We will now take up the second division of the subject: "Mechanical Defects, their Causes and Results."

The Pennsylvania Railroad specifications now under consideration for adoption by the Master Car Builders' Association accept wheels that do not vary more than $\frac{3}{32}$ in. from a true metallic ring placed over them. To place such a ring over a cast surface, not tooled, would certainly take $\frac{1}{32}$ in. all around, making up $\frac{4}{32}$ or ⅛ in. All things considered, to make castings weighing ¼ of a ton and over, true to $\frac{1}{16}$ in. to center as they come from the foundry, is remarkably good practice.

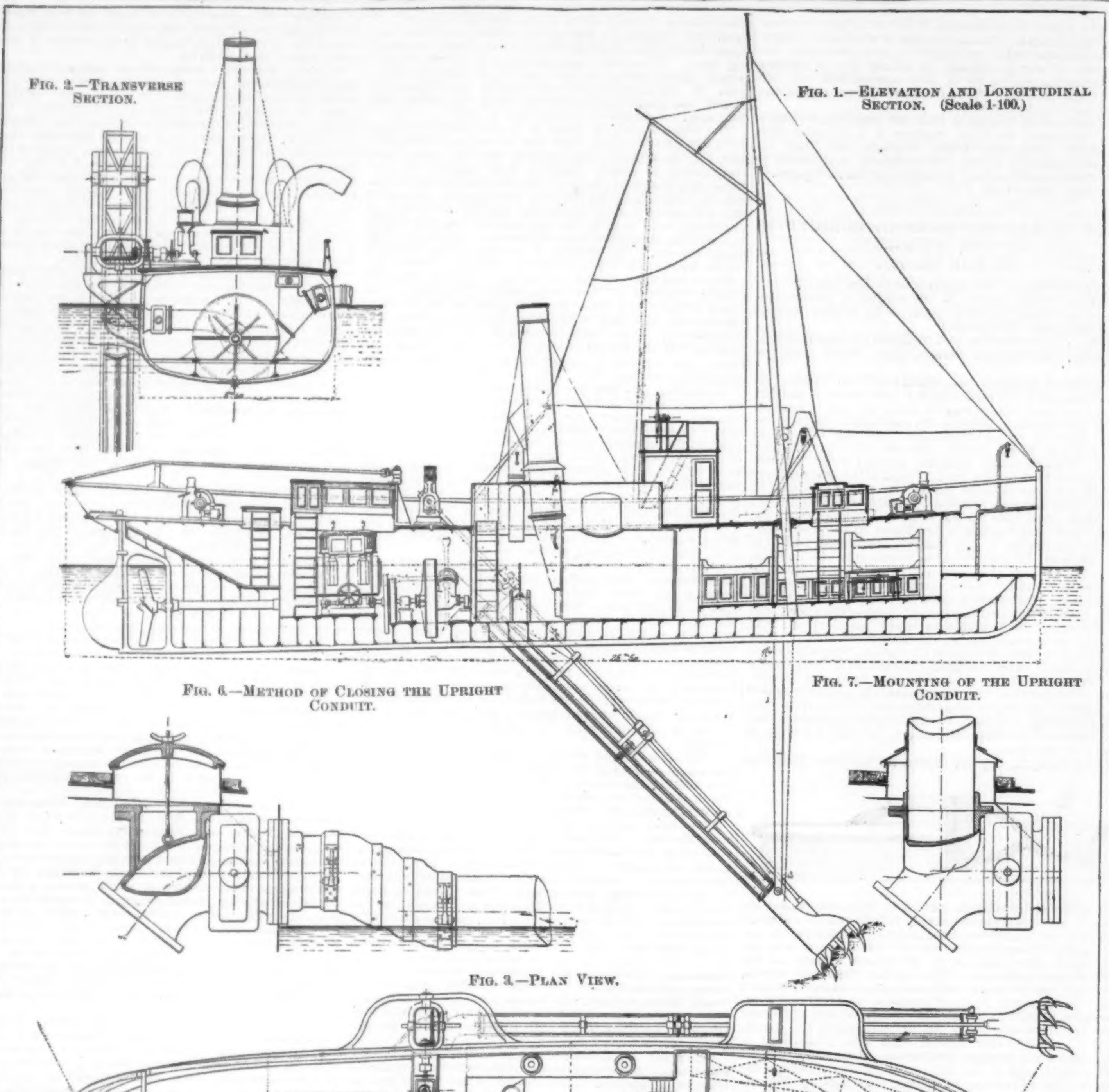
The load on a wheel is say 5 tons, the speed 30 miles per hour, the variation in diameter from its mate $\frac{1}{16}$ in.—diameter 33 in. The larger wheel will gain 3⅓ times $\frac{1}{16}$ in. at every revolution. It will revolve 611 times and would travel, if it could, 10 ft. more in every mile than the smaller one. Of course, it cannot do that; the flange would not permit it; but it gets on somehow, pulling and hauling, grinding and wearing, carrying its heavy load all the time with probably nearly as much power wasted in overcoming defective conditions as would be required to do the real work if proper ones existed.

Again, take the matter of balance. Take the very low estimate of 5 lb. as the amount each wheel is out of balance; I have seen wheels five times that amount out. At 30 miles per hour a 33 in. wheel revolves 306 times per minute. Fifteen hundred and thirty pounds must be swung around the circle described by its circumference every minute on every wheel under each car (eight wheels), therefore 12,240 lb. must be swung around every minute; on 30 cars 367,200 lb. or 184 tons must be moved that often. What power is required to swing 184 tons around a 33 in. circle once a minute for 320 minutes—the time it would take such a train to run 100 miles? Remember this calculation has nothing to do with the motion of the train; when that is considered, fresh questions arise. What effect does it have on retarding motion?

It may be that the support of the wheel on the rail counteracts to some extent lack of balance, but there is ample margin for all possible allowance that way and still have a remainder that is rich in possibilities. The precise nature of these results would be exceedingly difficult to get at by computation: It could only be determined by actual test of perfect conditions as against ordinary ones. The larger wheel unquestionably leads at all times, and the smaller one necessarily draws behind. The greater the load and higher the speed, the more certain an extreme condition of this kind will prevail. With the flange grinding the rail instead of running free, power is wasted and undue wear occasioned. It is difficult to locate loss of power or rail wear caused in this way in specific cases, but when the car wheel speaks, the whole story is told. Flange wear is the leading cause of wheel failure to-day in every type of wheel, and it has grown in exact proportion to the increase in load and speed.

It would take too long to follow the work up in all its stages; how one thing led to another, and so on. But some six years ago the point was reached where a definite system covered every wheel made as an individual thing. This, of course, mainly concerned the wheel as it came from the foundry. It was possible to know whether each one was of proper quality and to have full information on that matter. In the effort to improve, the mechanical features of the question were opened up and followed, until to-day the wheel leaves the foundry perfect as it can be made there. But not to go to the railroad shop to have, perhaps, 15 minutes spent in putting a hole through it and pressing it on an axle as the sum total of preparation for the most arduous mechanical work known. It goes to the machine shop, where it is bored out, turned absolutely true and balanced. Many say that this is unnecessary and useless work; that it decreases the life of the wheel; that the skin (?) on the chilled surface is the vitally valuable thing that must not be touched by the maker; that a difference in diameter is of no particular account; and that as to rotundity and balance, perfect castings can be turned out of the foundry. The writer has spent nearly twenty years in the foundry; learned the trade and worked at it for years; is fairly well posted in what is theory and what is practice. If the machine shop has no part in the preparation of a car wheel for a service many times more severe than any other mechanical one, there can be little value in all the other details of mechanical work carried on there. The writer has yet to find any wheel maker who has had a proper practical experience in the foundry say that wheels can be cast mechanically perfect. No doubt in certain instances with perfectly new tools, chills, etc., and special effort to produce the best result, castings can be made far more perfect than the average. But what about everyday prac-

* Abstract of a paper read before the American Society of Civil Engineers.



COMBINED STEAM TUG AND SUCTION DREDGER.

tice? Chills do not always remain new; ordinary workmen must sooner or later attend to the details. Is it possible to expect a good general result from conditions that will only produce it under special treatment that cannot be given in every case?

So long as this question is determined by foundry practice alone and wheels are used as they come from the foundry, it is certain the conditions necessary will not be obtained. It is necessary to find a true center and finish a wheel from that in a mechanical manner to obtain a proper mechanical condition. One of two things will certainly have to be done. Railroads will have to adopt steel wheels, for the mechanical work on which they seem willing to spend hundreds, yes, thousands of dollars, where they question that many cents to obtain in chilled precisely what they seek in steel wheels, or they will have to turn and balance chilled wheels. They are progressing step by step to heavier loads and higher speeds; they are forced to. They are equipping freight cars with air brakes. For what? That cars may carry more and run quicker. It is one thing to apply the brakes on a car which, with its load, weighs 30 tons and runs at 30 miles an hour, and have a brakeman do the work of transferring the power of one man through a 1¼ in. brake mast, with a leverage of 6 to 8 in. from center; and it is another thing on a train running at double the speed, with double the load, to put at the command of the engineer on a train of 30 cars a power of 50,000 lb. per car for instant use. Think of it! If the air brakes are in proper condition on such a train, the engineer has stored up in the air tanks under the cars a total force of 750 tons available for instant use. It will probably make some difference under such conditions whether wheels are round or balanced. It is making the difference now.

At best it is difficult to say what the entire result of the imperfect conditions referred to are in the practical operation and expenses, but as a conservative statement, based on long and careful investigation of the subject, the writer believes that with mechanical conditions such as they should be and such as can be maintained without difficulty on chilled wheels, the cost of power operating traffic carried over them can be decreased from 15 to 20 per cent. The cost of wheel service can be decreased from 25 to 50 per cent., and the saving in wear on equipment and permanent way will be in like proportions.

There seems to be some inexorable law that ties some purchasers of chilled wheels down to a price that would not buy common iron castings, and that compels them to hold all wheels of that class as of one value and quality. Thirty-three inch wheels, weighing 600 lb., are sold commonly to-day for prices that do not net the maker $8, freight and other expenses considered—a net price of 1⅓ cents a pound. The best car wheel iron cannot be bought for such a price, and just how the purchaser expects the manufacturer to furnish fuel, merchandise of all kinds, plant, labor and the general expenses of the business, and produce a good article, is a hard question to answer. Fortunately all wheel buyers do not follow such a practice, but so many do that the others think that a dollar or two more should produce something extraordinary, when as a matter of fact they pay more per pound of their brake shoes than they do at the highest price for wheels. If improvements in this matter are to be made, it must be considered from all standpoints and the same influences brought to bear upon it that have produced the highest type of modern engineering—the modern railroad.

The "connecting link" must be made as perfect as the parts it connects.

COMBINED STEAM TUG AND SUCTION DREDGER.

WE represent in the accompanying figures a new type of tug and suction dredger very recently constructed by the Henri Satre establishment for the port of Pernambuco, Brazil.

We need not dwell upon the numerous services that may be rendered to contractors of port works by such an apparatus, which unites within itself all the qualities of a powerful tug boat and a true suction dredging machine.

In the experiments on sea navigation made at Saint Louis du Rhone, between the Saint Louis and Sainte Marie lighthouses, this boat exceeded the speed of 9 knots per hour that is habitually required of good tug boats. Employed as a suction dredger, the apparatus is capable of sucking up earth from depths of from 35 to 40 ft. or more, and of emptying it either upon lighters or upon a bank at a great distance, by forcing it through conduits on floats.

As shown in Fig. 1, this boat is constructed and arranged like an ordinary steam tug. The hull is divided into six compartments by five water-tight bulkheads. The fore and aft extremities are designed for the various store rooms.

Back of the first forward bulkhead is found the crew's quarters, and back of these, on one side, is the captain's cabin, and, on the other, that of the mate. These quarters, as well as the cabins, are suitably arranged and contain bunks, folding chairs, closets and washstands.

Between the fourth and fifth bulkheads is located the motor, on each side of which there are closets, coal bunkers and tanks of fresh water. Upon the deck, beneath the bridge, is arranged the galley, which is provided with stoves and all the cooking utensils necessary.

The vessel is schooner rigged, with one mast, and a jib, foresail and brigantine sail. The engine, which is of the vertical type, compound system, is capable of actuating alternately, through gearings, either the screw shaft or the centrifugal suction pump. We shall recall here that in the experiments on power, the motor developed, with natural draught, a power 32 per cent. greater than that prescribed, and the consumption kept constantly below two pounds per horse and per hour.

The suction pipe placed at the side of the boat is made of strong steel plate, and is strengthened with angle irons throughout its entire length.

It is jointed at its upper part, so as to permit of dredging at various depths. This pipe is suspended by a swing bar and is guided in its motions by a frame made of I-iron and angle irons. The disaggregating apparatus (Figs. 8 and 9) is actuated directly, through a shaft in two parts connected by a Cardan joint, by a special motor placed upon the deck. The disaggregating wheel carries knives of a helicoidal form, in order to facilitate the introduction of the earth into the suction pipe. Eight of these knives or blades point forward and eight operate upon the circumference. The choking up that might occur in shifting earth is thus prevented by a proper division of the material and a sort of regularization of the proportions of the mixture of water and earth.

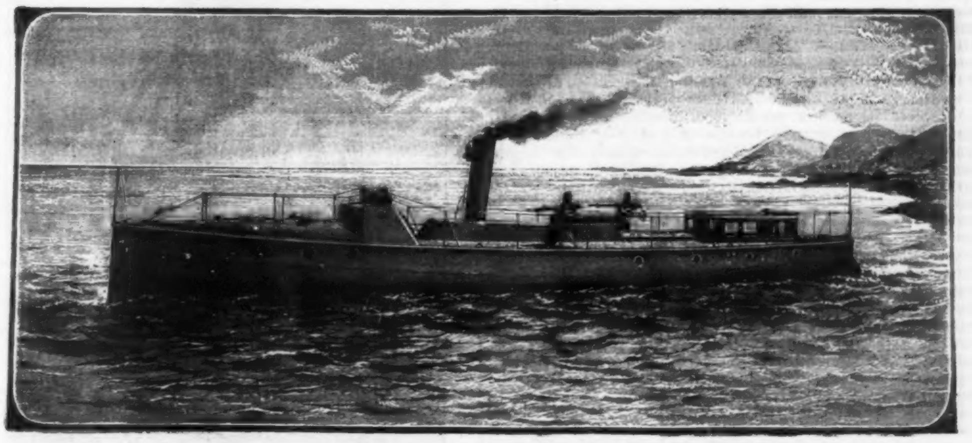
We call attention more particularly to this disaggregating apparatus, the judicious and well elaborated arrangements of which permit of dredging even in compact earth. It is to its great efficiency that is due the remarkable results obtained in the experiments in dredging on the maritime Rhone. Although there had been anticipated and required a mean rendering, at a depth of 36 ft., of 20 cu. ft. per indicated horse power absorbed, and per hour, the mean of the amount extracted at this depth under water was 37 cu. ft. The approximation of these figures needs no comment.

Figs. 4 and 5 represent the two ways of emptying the spoil. In one of them, the conduit first rises vertically and is then curved so as to empty the material into a lighter with movable bottom lying alongside of the dredger. This curved pipe is dismounted for the forcing of the spoil into the floating pipes, and the opening that results therefrom is closed with a plug. In Figs. 6 and 7 may be seen the arrangements adopted for the junction of the conduits.

It is unnecessary to say that this boat is provided with the steam windlasses necessary for backward and forward maneuvers, and for raising the suction pipe frame, etc. Upon the whole, it is possible to derive great advantages from such an apparatus, which, with its double function of steam tug and suction dredger, is of the greatest utility for the execution of work in ports. —*Revue Industrielle.*

NEW HIGH SPEED GUNBOAT.

SPEEDS of twenty knots and upward have of late become so common in torpedo boats that public interest is no longer excited by such results. Those of our readers who are familiar with the laws governing the resistance of floating bodies are well aware how great the difficulty is to secure high speeds in small vessels, and although it is now a simple matter to obtain 20 knots or more with a length of 100 ft., it is very far from easy to get this result in a vessel of 60 ft. Our illustration represents a small revenue gunboat which Messrs. Yarrow & Co. lately constructed for one of the South American governments, destined to act against smugglers on the coast. She is 60 ft. in length by 9 ft. beam, and the mean speed obtained on the official trial of one hour's duration was fully 20 knots, being a remarkable result when it is borne in mind that the beam adopted was sufficient to give good sea-going proportions.



NEW HIGH SPEED GUNBOAT.

This little craft is built of galvanized steel, is provided with triple expansion engines, and has a water tube boiler of the type patented and introduced by Messrs. Yarrow & Co., full particulars of which were given in our issue of January 16, 1891. It will be remembered that this design of tubulous boiler is probably the simplest now before the public, the tubes being all straight and every part accessible for examination or repair. Messrs. Yarrow & Co. have already built many of these boilers, and their performance in actual service is all that can be desired. The power obtainable in boilers of this type is from 90 to 100 horse power to the ton, which undoubtedly represents a step in advance in obtaining power with the least possible weight. The boiler was made entirely of steel, and to reduce corrosion as much as possible was galvanized whole after completion.

The annexed table is taken from the official report of the trial, which was made at Long Reach on the river Thames, and consisted of six runs—three with and three against the tide:

Steam.	Vacuum. Inches.	Revolutions per minute.	Time. M.	Time. S.	Speed.	Mean speed.
168	22	637	2	56	20·454	
171	21½	634	3	7	19·251	
173	23	649	2	55	20·571	20·030 knots = 23 statute miles.
171	22¾	642	2	59	20·111	
165	22	640	3	5	19·459	
164	21½	633	2	57	20·336	

Our engraving shows the general arrangement and armament of the craft, which is decked throughout and is thoroughly seaworthy. In the forward part there is a cabin with the conning tower at its after end containing the steering gear. Next to this is the boiler room and engine room, and further aft is a cabin as roomy as the dimensions of the boat will admit, in which there is comfortable seating accommodation for ten people. During the trial the steering capabilities of the boat were tested, and it was found that a circle at full speed was made having a diameter equal to 2½ times the length of the hull.

The armament consisted of two double barreled 1 in. Nordenfelt guns mounted on naval carriages, which was deemed amply sufficient to meet any contrabandists, and the great speed of the boat will enable her to overhaul rapidly anything likely to be met with. One point must not be overlooked in criticising such a craft, and that is the fact that in a boiler of the description adopted steam can be raised from cold water in twenty minutes. When it is borne in mind that to secure a speed of 20 knots about 300 horse power is necessary, it is certainly an exceptional performance to obtain so great a power within such limited dimensions, and this is mainly due to the type of boiler, which in this case developed 100 horse power to the ton, including water. The little vessel was shipped whole, her machinery being undisturbed.—*The Engineer.*

HOLZAPFEL'S FLANGED PLATE SYSTEM OF SHIPBUILDING.

DURING the past quarter of a century many remarkable improvements in the direction of economizing labor and reducing productive cost have been made in the methods of working out the structural details of shipbuilding. The present writer can remember a time when every plate and every bar destined to form a component part in a ship's structure had to be fixed temporarily in the position it was meant to occupy, in order to undergo the necessary preparation for punching and shearing. The wood template, which enables the workman to dispense with the temporary fixing of plates and bars for "marking," is not, of course, a modern invention; it has indeed been in almost universal use in this country for over twenty years. It had, however, to encounter a good deal of opposition at the beginning, and the fact that so obviously useful a contrivance should have been reluctantly adopted illustrates very aptly the popular prejudice which has existed in all epochs against new methods of carrying out constructive works. The wood template, though it only effected an economy of labor, has undoubtedly contributed to the rapid development of iron, and subsequently of steel, shipbuilding; but since its adoption other aids to progress have been introduced, which have had the effect of economizing not only labor, but material also. Among these may be mentioned what is known as the Z bar, now largely used for framing purposes, which combines in itself both frame bar and reverse bar; and the overlap joint in shell plating, which also lessens the cost both of labor and material. The adoption of steel as a material in substitution of iron led to other constructive changes, such as the arrangement of the plating in longer sections, thus reducing the number of "butts" or "joints," and consequently the amount of riveting work to be accomplished. The whole of these changes are, of course, the result of gradually widening knowledge, combined with that spirit of enterprise which impels the men who are imbued with it to incur great risks in the hope of furthering the projects upon which their minds are bent. The changes indicated have unquestionably been advantageous, and have done much to lessen the cost of vessels, as well as to increase their suitableness for purposes of commerce. It remained for Mr. A. C. Holzapfel, however, to introduce a principle in ship construction which is certainly the most radical, and will in all probability turn out to be the most valuable change in a commercial sense, that has yet been heard of. We allude to the method of constructing ships with flanged plates, which has been patented by that gentleman, and the efficiency of which has just been practically tested by the launching of the steel barge Alpha, which event took place on the 16th Nov., 1891. This little vessel has been built throughout in accordance with the new method, frames being entirely dispensed with, and the requisite rigidity being secured by a system of flanged shell plating. The whole structure, in fact, consists of nothing more than the shell, with two stout bulkheads (built also of flanged plates), a short stretch of deck at each extremity, and a 15 in. width of stringer running along the sides of the hatch. She is probably the lightest craft for her size that has ever been built of steel, and will combine the advantages of affording large cargo space with a comparatively small displacement. The flanges of the plates, in both shell and bulkhead, form a series of keelsons or stiffening mediums running from stem to stern, as well as from keel to deck and gunwale, and it would be difficult to imagine any arrangement calculated to give greater strength with the same amount of material. The method of connecting the plates by first shaping them with flanged sides and ends, and subsequently placing them together with the flanges forming the area of impact, fulfills another important purpose besides that of giving exceptional stability to the structure, and this is that the whole of the riveting can be done by hydraulic power, in substitution of hand work. This, it seems to us, is the most important feature of the new system, and it is undoubtedly the one which will most strongly recommend it to the notice of practical men.

It is a feature which has been long sought after, as it has always been felt that the application of hydraulic riveting to the shell work of vessels would result in a reduction of cost, as well as an improvement in quality. It is indeed a fortunate circumstance that a solution of the problem of closing shell rivets by hydraulic power has at last been found; for the method now in use of doing the work by hand labor is, from many points of view, unsatisfactory. The bottom of a vessel, which is after all the most vulnerable part, or at all events the part most likely to suffer damage from contact with sunken rocks, can scarcely be riveted in a thoroughly sound manner by hand riveting, owing to the fact that the workmen having to strike at the rivet in an upward direction, cannot close the work so effectually as if they were striking horizontally or downward. Thus, with the present method of riveting, the part of a vessel which ought to be strongest is usually the weakest, and all will admit that this is a fault in ship construction which urgently calls for a remedy. It is tolerably clear that with the system of plating by overlapped edges, no appliance could be devised which would enable hydraulic power to be applied to shell riveting, the network of frames, keelsons and other sectional parts presenting an ever-present aggregation of impediments which, we think, would continue to be found insuperable. Mr. Holzapfel, we imagine, must have devoted a good deal of thought to the subject before it occurred to him that the only way to surmount the difficulty was to adapt the work to the machine instead of the machine to the work, and by his system this is satisfactorily accomplished. The use of flanges on the plates admits of all joints being reached by a riveting machine suspended from a traveling crane, and the absence of frames and other obstructions must greatly facilitate the operations of those engaged in the work. Some doubt seems to exist in certain quarters as to the practicability of applying this system to the building of large vessels; and it would be a miracle, indeed, if such an innovation were received without a good deal of hesitation being manifested among those who have been trained to the practice of the method now in use. As a matter of fact, we do not think it is the intention of Mr. Holzapfel and the gentlemen associated with him to attempt the construction of large vessels until they have had time to develop the new system in the building of such vessels as the Alpha. Years of patient trial have been spent in perfecting most other great inventions, and it would be unreasonable to expect that this should prove an exception to the general rule. The application of this new system of shipbuilding, so far as it has been exemplified in the construction of even so small a vessel as the Alpha, has, we have reason to believe, afforded the inventor an opportunity of improving upon his idea, and the results, we have no doubt, will be seen in the building of future vessels of a similar class. The yard of Messrs. Swan & Hunter, at which the Alpha was built, though one of the most admirably appointed in the country, is not particularly well adapted to the requirements of this system, and when the inventor is in a position to apply his method in an establishment specially fitted up for the purpose, widely different results, both in the cost of building vessels and in the time occupied, may be confidently looked for. We understand that arrangements are now being made for the acquisition of a building place on the Thames, wherein the system can be applied, under conditions which will admit of its merits being fully and fairly tested. We have omitted to mention that the punching of the flanges, as well as the riveting, will be done by a hydraulic machine after the plates are placed in position, thus securing absolutely fair rivet holes, besides doing away with an immense amount of labor, and rendering unnecessary the presence of cumbrous and costly punching machines, such as are now used in shipbuilding.—*Marine Engineer.*

NAVAL TRANSFORMATIONS.

To the Editor of the Scientific American:

In your issue of Dec. 19 last, on page 384, is an editorial article on "The Engineer and the Sailor," in which you show conclusively that the commanding officer of a warship nowadays must either be a sailor or that the engineer officers must have more latitude, etc.

Allow me here to call your attention to an article written by the late Rear Admiral J. A. Dahlgren, U. S. N. (who died in 1870).

It occurs in the introduction to his pamphlet on "Bombshells," 1838, and was prophetic.

Lieut. John A. Dahlgren, U. S. N. (afterward Rear Admiral, U. S. N.), wrote as follows in an introduction or preface to a pamphlet translation on "Shells" (bombshells), published in Philadelphia in 1838.

"The spirit of change that has wrought so many wonders in our new country is at last extending itself to another and far different field of action; it now bids fair to make and maintain

"Its march upon the mountain wave,
Its home upon the deep."

. . . .

The spell is now on blue water, and the decree has gone forth against the time-honored fabrics that have so long "braved the battle and the breeze;" all the graceful pageantry of flowing white canvas, and the interminable but well ordered tracery of rigging must disappear before its influence; even the blast of the gale amid the strained cordage will no longer whistle "soft music" to the ear of the hardy seaman; snug reefs and leeway will be things of another time, and in their stead we tighten the screw, oil the machinery, and poke the fire.

Among the mighty agents of this change none can compare with steam—as yet in its infancy. Numberless difficulties await its career of utility; but experience will remedy all these.

The day may even be not far distant when the topsail shall no longer need a reef, nor the to'gallant sail shiver in the squall; the good ship will be snugly moored at the dock, and all her glorious panoply lie neglected in the store room, for the moth and the rat to prey upon.

In all this the sailor sees nothing but unthinking and unwise experiment; his heart is with the gallant vessel that has borne him on many a wave. With his honest but ignorant sorrow may not the veriest utilitarian sympathize?

The haughty three-decker then is doomed, after all, like the steel-clad knight, to be but the wonder and the riddle of another age."

It must be remembered that in 1838 there had only been two steam vessels in the navy, viz., the Fulton, blown up in 1829, and a small tender to Commodore Porter's fleet operating against the pirates in the West Indies. Several large war steamers were projected, but none were afloat.

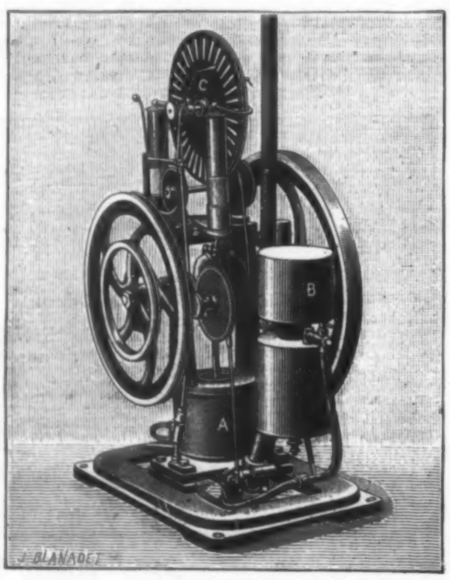
The above, in the light of subsequent events, seems to have been prophetic. This same foresight applied to the coming of rifled ordnance, and he (the inventor of the most perfect and successful system of smooth-bore ordnance in the world) saw its approach and even solved many of the earlier problems of what is now the armament of the navies of the world. With increasing years he said, "I have done my share, others will take up my task and carry it on."

C. B. DAHLGREN,
Trenton, N. J. late U. S. N.

A DOMESTIC PETROLEUM MOTOR.

DESPITE the rapidity with which distributions of electric energy are now being established at Paris, many years are yet to come before the free arrangement of the electric current will be assured on most inhabited estates.

It will possibly often happen, though, that a person who recoils from the expense of an installation designed to replace lighting by gas will nevertheless desire to light a few electric lamps. In such a case, a feeble source of energy suffices. The problem has been tried several times up to the present, but always with slight success. Gas motors which sometimes render services were here becoming cumbersome and difficult to use. Petroleum motors were then tried, and certain apparatus of this kind have operated with regularity under several circumstances. We have already made several of them known in these very columns. But, in all these motors, the power attained was quite high, and in but a few cases was it possible to produce that of about one horse. We desire now to present to our readers a small and easily used petroleum motor that necessitates no special installation, and is of but about half horse power.



DOMESTIC PETROLEUM MOTOR.

A, cylinder; B, carbureter; C, static machine for igniting the gas.

This motor is due to Mr. Gracchus Balbi. The apparatus, which is illustrated herewith, consists essentially of a cylinder within which moves a piston. The lower part of this cylinder communicates, through a rubber tube, with a small carbureter, or vessel filled with petroleum, which is provided with a tube for the entrance of the external air. When the motor is in operation, it presents four definite phases: 1, the carbureted air is sucked in and fills the cylinder; 2, the gas is compressed; 3, the gas is ignited by means of a special arrangement that we shall describe; 4, after combustion, the gases are expelled, and the same phases begin again.

Before giving figures as to the weight, size and other data, let us make a few observations upon the principles of the motor. The compression of the gases before their ignition is one of the greatest of the improvements introduced into motors of large dimensions. It is likewise utilized in the present case, and without any complication of mechanism.

The operation of the valves is assured in a very simple manner. The admission valve operates through the simple suction produced by the piston in the cylinder. The eduction valve is operated by a small eccentric which causes it to rise during a quarter revolution of the fly wheel.

The ignition of the gaseous mixture is effected here, not by means of batteries, but through a small static machine of the Wimshurst type, modified. Motion is transmitted to this machine by means of a small belt. The spark is produced, at each motion of the piston, between the two poles of the machine, by means of a special device having a to and fro motion. The circuit is closed by copper wires within the cylinder, wherein the spark likewise appears.

Cooling of the cylinder is assured by a circulation of water drawn by a small pump from the hollow base upon which the motor rests. The same water serves for several runnings. The pump requires but a slight amount of power for its operation.

We must mention, as a final improvement, the addition of a small centrifugal regulator, which arrests the entrance of the gases when the velocity exceeds a certain limit. We shall now give a few practical data concerning a model that we have had an opportunity of seeing in operation and of examining closely.

The motor (of about half horse power) weighs 144 pounds, is 32 inches in height, 24 in length and 16 in width. It rests upon a wooden base, under which there is a water reservoir of a height of 18 in. The total height of the apparatus is but about 4 ft. It uses about 6 ounces of petroleum per hour. The angular speed is from 300 to 380 revolutions per minute. In an experiment made by us, the motor, through a belt, actuated a small Gerard dynamo that supplied two Gerard lamps, which, accurately measured, consumed each of them 38 watts (15·2 volts and 2·5 amperes). We had, therefore, an effective power of 76 watts or 0·103 horse. The price of the motor is $76, while the price of a gas motor is $60. In the latter the consumption of gas reaches from 9,150 to 12,000 cubic inches per hour.

We believe that the small motor that we have just made known is destined to render the greatest services to all those who desire to have at their disposal a feeble motive power, and who cannot have recourse to distributions of electric energy.—*La Nature.*

THE MANUFACTURE OF GLASS POTS.

THE practical success of the "tank system" of glass manufacture has not as yet curtailed the demand for glass melting pots. These pots are composed of clay which is required to be as free as possible from lime and iron. A clay obtained from the carboniferous shales of Worcestershire, in the neighborhood of Stourbridge, England, is highly esteemed for the manufacture of glass pots. There are also several American and German clays which are suitable for the purpose of producing the large pots in which glass is melted and worked.

These clays are, first, Gross Almerode, near Coblentz, Germany, for bond clay; second, Christy clay, from near St. Louis, Mo., used for calcine and bond; third, Blue Ridge, Missouri, clay, used for bond and calcine; fourth, Mineral Point, Ohio, flint clay, used as flint and calcine; fifth, old pot shells for calcine.

The German clay is shipped as ballast in the holds of vessels, and hence transportation costs but little. It is an excessively fine grained and heavy clay, and is very plastic, making a better bond than any native clay. It comes in blocks 9×6×6 inches, which have to be pared with a draw knife, and then broken and inspected and all irony spots removed. No pieces larger than a walnut are allowed to go into the mixture. The work involved in getting the clay ready for use is excessive, and it is the opinion of those at the works that it is much overrated. It is an excellent bond clay, it is true, but its refractory properties are excelled by the Christy clay of Missouri.

These Missouri clays come in blocks, either calcined or raw. They are pared and broken but not sorted over. They are washed before shipping, so that they are much finer than in nature. The Blue Ridge is the finer grained of the two. The Mineral Point calcined clay is not now largely used, because the old pot shells, being already in the desired composition of the mixture, make a better calcine than any single clay.

These shells are chipped with small hammers until no part of the surface remains and only the clean interior is left. The charge is composed quite largely of calcine with a little flint clay, and the remainder German and Missouri bond clays. The mixture is ground in a dry pan and sifted in a jig bolt, and the coarse part reground. It is then pugged five or six times in succession and then is stored and blanketed. It remains in this state until it sours and smells offensively, which the men claim is necessary to its proper working. It is wedged by hand and is ready for use.

When required for forming the pots a sufficient quantity of the clay is taken and kneaded with one-fourth of its quantity of the material of old pots, which are ground to fine powder and carefully sifted; this material gives firmness and consistency to the paste, and renders it less liable to be affected by the heat. The pots are of two kinds, the opened and the covered. The first are used for melting common glass, such as window and bottle glass; the other for flint glass. In each case, the pots are made entirely by hand, and require great skill and care.

The pots are large structures about five feet high, four feet wide, and four feet long, bounded on top and sides by covered walls, and on the bottom by a flat face. They weigh from 2,000 to 3,000 pounds, and sometimes as much as 3,500 pounds. They are made from three to five inches thick, with a thicker floor, and are each built on a small platform covered with gravel, so that air may circulate beneath them and dry them faster.

The flint glass pots are only from two to three inches thick. Each builder has on hand twelve or fifteen pots at once, on which he daily builds a little more, until at the end of three weeks or a month he finishes them all together. The buildings in which glass pots are made are provided with elevators, so that the heavy pots can be handled without danger of injuring them.

When the bottom is finished, the workman begins to build up the side of the pot by first forming a ring of the same height all round, taking care to round off the upper edge to a semicircular curve of great regularity; upon this he begins bending over other lumps of the paste until another equal layer is formed, and these are continued until the pot is complete; the workmen spread wet cloths over the edges when they discontinue working. This is necessary, to admit of a certain amount of drying, otherwise the large weight of clay used would prevent the form being kept, and the pot would either fall to pieces or lose shape; the building of the pot is consequently extended over several days. After the potter has finished his work, the pots are removed into the first drying floor, where they are only protected from draughts, so that the drying may be conducted with the greatest possible uniformity. When they have progressed sufficiently, they are removed to the second drying floor, which is heated with a stove, and the drying is here completed. They are then placed in the store, where usually a good stock is

kept on hand, as time improves them, and they are seldom kept less than six or nine months.

The pots are shipped on three-wheeled trucks, which are returned to the works, so that they are loaded and unloaded with ease and security, where before there was always great danger of breaking them. The work must be under most intelligent supervision.

When required for use, the pots are placed for four or five days in the annealing furnace, which is on the reverberatory principle, and they are there kept at a red heat. This furnace is so situated that the pots, when ready, can be very quickly transferred to the main furnace—an operation of exceeding difficulty, and requiring great skill and dexterity, as they have to be removed while red hot, and it must be done so quickly that no sudden cooling shall injure the pot, a difficulty which can only be understood by remembering that the ordinary pots are nearly four feet in depth, are the same in width at the mouth by about thirty inches at the bottom, and they weigh several hundredweight. The enormous amount of labor bestowed upon these pots makes them very epensive, their value being from $30 to $50 each.

Their removal from the annealing oven to the main furnace is effected by an immense pair of forceps several feet in length, which are placed horizontally upon an upright iron pillar about three feet in height, which rises from a small iron truck on four wheels, so that the whole apparatus can be easily moved from place to place. By means of this instrument the pot is lifted and dextrously withdrawn from the oven, and as quickly transferred to its position in the main furnace, in which usually 10 or 12 are placed on a platform of fire brick or stone, each pot being opposite to a small arched opening through which it can be filled and emptied. The entrance to the main furnace, through which the pots have been introduced, is then closed, with a movable door of fire brick, and covered over with fire clay, to prevent the escape of the heat.

The material used in the construction of the arches as well as walls of large glass ovens is best produced from the Stourbridge or similar clay, which is carefully shaped into large slabs, and faithfully dried for more than a year; but it is not burned in the kiln.

Some of the leading manufacturers of fire brick keep on hand various sizes of jack brick, and are also prepared to make any special shape of jack or glass pot stopper that may be wanted, and keep them on hand for any customer using them regularly. For the crowns of furnaces, brick are made to any pattern that may be desired, but usually twelve inches long, with the lines tapering to suit the radial lines of the furnace. For those glass manufacturers who have mills and are prepared to manufacture their own shapes, the fire brick manufacturers keep a large stock of different clays on hand, calcined and green. The calcined clay should be all carefully selected and thoroughly burned.

For building the eyes of furnaces, repairing benches and making flue brick, etc., fire brick manufacturers carry a stock of batch clay, which should be prepared very stiff, so as to require thorough ramming in order to get it securely in its place; and the same stock when desired can be made into blocks to form the eye, and burned.—*Brickmaker.*

NEW METHOD OF PURIFYING GUTTA PERCHA.

By ALEXANDER GRAMMONT, Pont de Cherui, Isere, France.

UP to the present the purification of gutta percha has been performed mechanically, all the operations necessary being long and costly, and, in spite of care and time given to the process, it is difficult to obtain an absolutely pure product.

The improved method which forms the subject of this invention consists broadly in dissolving the raw gutta percha in a suitable solvent, and treating it to successive purifications while in solution. This refining process consists of three principal operations, which take place substantially in an automatic manner in the apparatus used for this process, and which also forms part of this invention.

These three operations are—first, the extraction of matters foreign to the ordinary composition of the gutta percha, such as earthy matter, sand, wood, water; secondly, the extraction and separation of the oxidized gutta percha, giving product No. 1; and thirdly, the extraction and separation of the resinous matters contained in product No. 1, and also in product No. 2, being the residue that remains after extracting product No. 1.

The method is carried out as follows: The gutta percha to be treated is triturated to reduce it to small fragments and placed in an iron or wooden receiver, in which are movable pallets or mixing devices. Bisulphide of carbon is then allowed to flow into this receiver from a tank placed on a high level. The agitator or mixer is then moved to stir together the bisulphide of carbon and the crude gutta percha until the soluble matter therein is all dissolved. A cock at the base of the receiver is then opened and the solution passes into a filter, which retains the solid matters not dissolved in the bisulphide of carbon, which foreign matters are thus separated from the gutta percha. The solution passes into a series of depositing vessels; in these vessels the oxidized gutta percha separates gradually from the pure gutta percha by reason of a difference in density. The pure gutta percha is drawn off into a lower vessel, in which the bisulphide of carbon is evaporated, leaving only pure gutta percha, containing, however, still some resinous matter.

The vapor of the bisulphide of carbon is carried off and condensed in a worm and returned to its storage tank to be used again for dissolving crude gutta percha. Two products are thus obtained, one being oxidized gutta percha containing resin, the other non-oxidized gutta percha also containing resin.

Before treatment to remove the resin, the oxidized gutta percha requires to be deoxidized, which may be done by passing carbonic oxide gas into the vessel containing the solution of oxidized gutta percha. The carbonic oxide gas removes the oxygen, being converted to carbonic dioxide or carbonic acid gas. The resulting deoxidized gutta percha may be mixed with the non-oxidized gutta percha, or these two products may be treated separately for removal of the resin, according to the quality of the ultimate product required.

To remove the resin, an apparatus is used similar to that employed for the first part of this process, or even the same apparatus may be used, if desired. Instead, however, of using bisulphide of carbon as a solvent, benzine, or essence of terebentine, or any other essential oil which dissolves resin, is used.

The solution is made in the mixer as before, passes through the filter into the depositing vessels, where the resin separates from the gutta percha, so that by simply drawing off at proper levels, the two products are separated. The gutta percha solution is carried to the evaporator, where the solvent is evaporated, to be re-condensed for use again, and the pure gutta percha is left in the apparatus. The oxidized gutta percha after deoxidation is treated in the same manner, and forms a product of secondary quality.

MANGANESE OXALATE AS A DRIER.

A WRITER in the *Moniteur des Produits Chimiques* draws attention to the properties possessed by manganese oxalate as a drier. This salt has hitherto not had any important industrial uses; but it can be readily prepared in a state of purity from the native carbonate by the action of oxalic acid. The author is of the opinion that it will be found of use for this purpose. If prepared from carbonate free from iron and lime, it can be obtained as a fine crystalline white powder, and two-fifths per cent. suffices to bring about the change. The oxalate is resolved by heat into manganese oxide, carbonic acid and carbon monoxide, and in the presence of fatty acids the manganese oxide formed combines with them, the decomposition taking place at about 130 deg. The operation is carried out by mixing in a mortar the oxalate with two or three times its weight of oil, and then adding the mixture to the main portion of the oil. The heat should be applied gradually, and the decomposition is known to be complete when there is no further evolution of gas. The boiled oil, under this treatment, preserves its limpidity and also remains colorless. Manganese oxalate has the advantage over oxide of lead, which is commonly employed for this purpose, in causing the oil to remain transparent when exposed to sulphur vapors. Manganese acetate has also been used, but it likewise causes a darkening in the color of the oil, and the nitrate is dangerous, owing to the possible action of nitric acid on the fats present in the oil. Manganese borate appears to be next in value to the oxalate as an oil drier.

SOLAR PRINTING.

A SUBSCRIBER says: I find that in developing solar prints a yellowish brown stain tinges as a resultant where nitrate of silver has been on. Can you give me a formula, say the latest formula, that will enable me to obviate this? Also after prints are "fixed" in solution and hung up in hot weather some turn yellow and others at the same time do not. Can you give or get an explanation of this?

Also R. O. asks: Will you please let me know of some formula for making solar prints? I have a serum or solution for seruming the paper Steinbacks, but am unable to iodize it, and let me know the price of Fownes' or Roscoe's chemistry and which gives the most definitions.

A.—The stains may be avoided by adding a little more citric acid. The yellowing may be due to insufficient fixing or washing after fixing. In Wilson's *Photographics* is given the following recipe and hints on preparing solar printing paper:

First make up the following serum solution—

Skimmed milk	½ gal.
Acetic acid, No. 8	3 ounces.

Stir, put it in a porcelain dish; bring to a boil, stirring all the time; strain out the curd through muslin (make Dutch cheese of this); take the serum, when cold, filter until clear.

Now add—

Iodide of potassium	16 grains.
Bromide of potassium	4 "

to each ounce of the clear serum. Float your plain paper on this until it lies smooth; see that no bubbles or spots rest on the paper; dry with moderate heat; prepare the paper in a room free from dust or actinic light, and if kept in a cool, dry atmosphere, it will keep in good working order a long time. To use, float two minutes in a solution of—

Silver	640 grains.
Water	16 ounces.
Acetic acid	2 "

Draw the sheet off the silver solution over a glass rod. Having previously focused your picture, place your paper, while damp, in position, and let on the light; print according to the density of the negative. A very hard negative requires printing until the detail is well out and developed with a *very weak* developer; on the contrary, a *very thin negative* need not show any detail, and must have a stronger developer, which is prepared as follows:

Pyrogallic acid	90 grains.
Water	33 ounces.
Acetic acid	2½ "
Citric acid (saturated solution)	10 drops.

This is for medium or good for printing contact negatives.

This class of negatives is what is required for making enlargements by development. For hard negatives, use less pyro; for weak, such as regular solar negatives, use more pyro. The old rule was to swab on both the iodizers and the silver; but in that way you are pretty sure to get streaks and stains in about half or more of the prints you try. In developing, lay the paper, face up, on a clean board, on which a clean piece of white bibulous paper is laid. Have the developer in a widemouth bottle. Commence at one end, and apply enough with one sweep of the hand to completely cover the print; now watch it grow. If stains or fog occur, either you have overtimed, or allowed actinic light to get at the print, especially so if the picture pops out quick and then blackens all over. If it comes up slowly and stains from this cause, add more citric acid. As soon as developed, plunge it in clean water, and from that to the hypo, for clearing, of usual strength; then wash as usual. Thick paper needs longer and stronger cleaning than thin. If the print comes up too flat in developing, add a little acid silver solution to the pyro. The price of Fownes' chemistry is $3.75.

PICTORIAL TELEGRAPHY.

THIS process is the invention of Mr. N. S. Amstutz, of Cleveland, O., and is known as the electro-artograph.

The process is founded on the use of undulatory or varying currents of electricity, somewhat on the principle of the telephone—the transmitting instrument being actuated indirectly by the varying degrees of light instead of by sound waves, as with the telephone transmitter. To send a view or a portrait it is photographed on what is known as a "stripping film," composed of gelatine and bichromate of potassium. This mixture, as is well known, is sensitive to light, becoming exceedingly hard and insoluble when exposed, but readily dissolved where shielded from the light. A picture having been taken on a film of this kind, either by exposure, in a camera, or, preferably, by printing through a negative, it is carefully washed with lukewarm water, which removes the portions not acted on by light, and leaves the other portions in relief. So far, there is nothing new in this process, which has long been used for newspaper work, and forms no part of Mr. Amstutz's invention. By this operation the amount of relief is in exact proportion to the light which has acted upon the gelatine, and there is produced a variable surface representing in elevation all the variations of light and shade of the picture.

This film is now stripped from the glass plate and mounted upon a sheet of celluloid, which is wrapped around a perfectly true cylinder mounted on trunnions, so as to permit of revolution. In front of the cylinder is placed a bar, upon which rides a carriage containing a tracing point, which bears lightly upon the gelatine print, just as does the stylus of the phonograph upon the wax cylinder. In the latter the needle trips over the indentations produced in the wax by sound waves, and reproduces them in kind. In the former it rises and falls according to the greater or less relief due to the varying degree of light to which the film has been exposed, and by so doing varies, in a corresponding degree, the intensity of the electric current which actuates the receiving instrument. Thus far the analogy is very close to a telephonic transmitter, actuated mechanically by the diaphragm of a phonograph. It is clear that if this current can be caused to vary exactly as the elevations over which the stylus passes, the varying strength of the current at the distant point, if plotted, would be an exact fac-simile of the path described by the needle, or, as engineers would say, it would reproduce the profile of the path originally described. Now a single line does not make a picture, although it may form one element of a picture, as it does in this case. To transmit the picture, therefore, the whole of the gelatine film is gone over, the stylus describing a spiral around the cylinder, with its returning paths quite close together, just as the phonograph stylus describes a spiral from end to end of the wax cylinder, and this is accomplished in exactly the same way.

Now, if the carbon button, which permits of sufficient variation in current for the transmission of speech, permitted of sufficient variation for this purpose, there would probably be no better way of varying the current than by its use, but carbon has not this flexibility, and Mr. Amstutz had recourse to another method. The "tracer," as he calls his stylus, is mounted upon a lever, which largely multiplies its up and down movement. This engages with a series of levers mounted on a common shaft, the further ends of these levers being platinum pointed, and serving, when depressed, to connect the source of current with the line wire. The current enters the machine through this common or tappet shaft, as it is called, and passes to line through the one or more contact points that happen to be depressed into contact with a plate connected with the line wire.

The action is this: Supposing the tracer were on a point of highest relief, only one of these levers would be depressed and the current would have but a single contact to pass through. Supposing, now, the tracer came across a place with slightly less relief, a second lever would be depressed, decreasing the resistance and permitting more current to pass, and so on until, on passing a point of lowest elevation on the gelatine print, all of the levers would be depressed, reducing the resistance to the minimum and permitting the maximum current to pass. Of course, the more of these levers there are, the more gradual the variation of current strength sent over the line. The number of these levers or tappets is not limited, but may be anywhere from two to fifteen or twenty, or more, according to the character of the work to be done. The larger the number, the greater the accuracy of the reproduction. For long distance transmission, especially for newspaper work, a large number of tappets is not desirable, since the degree of delicacy obtained thereby would certainly be lost on the rough paper and in the rapid press work to which it would be subjected; for all practical purposes a less number of tappets would produce equal results in this kind of work. Furthermore, the adjustment of the sending machine to the varying thicknesses of different gelatine prints does not affect in any manner the receiving machines, so that a picture sent with great delicacy may be received in the newspaper office in sufficiently crude form for its purposes, whereas another machine connected with the same wire and receiving the picture at the same time could reproduce it with the same delicacy with which it was sent—all depending upon the adjustment of the receiving instrument.

The receiving machines are duplicates of the sending machines as far as the cylinder, the carriage, feed, etc., are concerned—the only difference being the graving arm, which is depressed by an electro-magnet whose strength varies as the current by which it is excited. It is clear that when the transmitting instrument is passing over a low place in the gelatine film, and all the contacts are down, permitting the maximum current to pass, the electro-magnet of the receiving instrument will be at its maximum strength, and the

graving tool correspondingly pressed on the receiving matrix and *vice versa*. The receiving cylinder is wrapped with paper covered with a suitable thickness of hard wax. This wax is turned off by a turning tool preparatory to use, just as is the cylinder of the phonograph, and when the impression is complete the waxed paper cylinder is removed, cut longitudinally and rolled out flat, and is ready for the electrotypers.

As an illustration of the manner in which a picture is received, let us assume an hypothetical case. Suppose the wax used to be white and we color its surface black. Suppose the cylinder to be started, and the graving tool but slightly depressed. A very delicate white line with slight depth will be traced. If the same pressure be maintained for several revolutions, there will appear a series of delicate white lines running closely parallel to each other. Now suppose the tracer on transmitting instrument to be passing over a portion of the gelatine print of greater depth, more current would be transmitted, and the triangular shaped graving tool would cut deeper into the wax, the white line would be broadened and the intervening black line made correspondingly narrower. A step further; when the tracer is passing over those portions of the film that are not intended to print at all, the graving tool will be buried so deeply in the wax as to cut away the black entirely, and in the electrotype made from this matrix this portion would be entirely cut away, so as not to print at all, thus producing in metal a line fac-simile of the gelatine relief from which it was originally produced. Thus it is seen that by variations in pressure of the graving tool all the gradations of light and shade found in the picture on the transmitting instrument may be faithfully reproduced on the receiving cylinder, and then in metal by the electrotype process.

Mr. Amstutz has also succeeded in reproducing impressions in papier mache directly from the wax, so that the engraving can be directly stereotyped in the ordinary manner.

The time occupied in transmitting an ordinary column wide illustration need not exceed eight or ten minutes, and the stereotyping of the reproductions should not occupy more than a few minutes more, so that the reproduction can be placed upon the newspaper printing presses along with the press dispatches descriptive of the subject to be illustrated.

By a system of gears on both the transmitting and receiving instruments, it is possible to change the size of the picture at either end of the line. That is to say that a picture can be transmitted either larger, the same size, or smaller; and at the receiving end, if there be several instruments, they may each reproduce it on a different scale. Of course much greater accuracy is attained if large originals are used and they are reproduced on a smaller scale.

A single transmitting instrument is capable of actuating a large number of receivers at different points; thus the same picture may be simultaneously reproduced at a number of widely scattered news centers.

If it is desired to send hand sketches, a process has been devised by which a special artist can make his sketches "on the spot" by suitable washes, preserving all the half tones that he may deem necessary to the correct pictorial representation, and upon the completion of the sketch it is wrapped round a transmitting cylinder, and by a simple adjustment of the tracer, the machine can be left to itself until the whole picture is transmitted to its destination, where it is automatically reproduced, a complete line engraving.

It is claimed for this process that the depth of engravings can be increased over 100 per cent. above that reached by the deepest half tone engravings, thus adapting the work to uses for which the latter, on account of their shallowness, are unsuited.

Besides the use of wax as a receiving substance, Mr. Amstutz says it is quite possible to engrave directly on metal; and he expects to find large application of his device for reproducing portraits, photographs and conventional designs, both singly and in multiplicate, on silver and other metal ware, principally at local points.

The foregoing is from *Electricity*. The examples we have seen are rough productions, hardly worthy of the name of pictures.

PURIFICATION OF WASTE WATER BY ELECTRICITY.

WEBSTER'S method of purifying waste water has, says the Berlin correspondent of the *Lancet*, been tested by Dr. Fermi in the Hygienic Institute in Munich, and he has communicated the result in the last volume of the *Archiv für Hygiene*.

The electrified waste water, he says, purifies itself in about 15 minutes. The dissolved organic substances are reduced by about one-half, and the suspended substances are either precipitated to the bottom by the ferric hydrate formed on the surface of the iron electrodes, or gather on the surface of the water. The smell of the water is perceptibly improved. The oxygen generated by the electrolytic decomposition of the water and the chlorine set free by the decomposition of the chlorides gather on the positive electrode, the ammonia developed by the separating of nitrogenous substances on the negative one. The method has two considerable advantages. The first is that very little iron is precipitated, and its removal is therefore not so difficult as in the case of water purified by chemical methods. The second is that the dissolved organic substances, which are not precipitated by any of the chemical methods hitherto applied, are at least partially got rid of by the electric current. The stronger the current the larger the surface of the electrodes, and the longer the electrization lasts, the quicker and completer is the purification. The organic substances contained in a liter of water can be reduced by two-thirds in one hour by an electric current of 0·5 to 1·0 ampere with flat iron electrodes 80 cubic centimeters in size and five centimeters apart. The number of germs is thus diminished fifty or a hundred fold. The purifying effect of such current, however, is less reliable than that of the addition of 1 per cent. of lime, which completely frees the water of germs and keeps it free, whereas in the electrified water the germs multiply again fivefold in 48 hours. Weaker currents, even when applied for a longer time, give no better results. In contrast to most of the known chemical methods some oxidizable organic substances are reduced in quantity by the electric current. Electricity seems not to realize the ideal of the purification of water, but it is certain to compete formidably with the chemical methods, and the method will probably be greatly improved.

SECONDARY BATTERIES.*

By G. H. ROBERTSON, F.C.S., Assoc. Inst. El. Eng.

INTRODUCTION.

THE secondary or, as it should rather be called, the reversible battery dates practically from the discovery that electric currents could be produced by the agency of chemical actions, and its development progressed with the increase of our knowledge of the laws which govern electrolysis.

In the year 1800, Volta discovered that a current could be obtained through chemical agency, and in the following year Gautherot observed that when electrodes of silver or platinum wire were used for the electrolysis of acidulated water, they gave a current in the reverse direction to that in which the battery current had been passing, if they were connected through a galvanometer directly the battery was removed.

These inverse, or polarization, currents, as they were called, were a source of great perplexity, and although much work was done on the subject, and many theories started to account for their origin by Volta, Ritter, Marianini, Becquerel, Grotthus, and others, no satisfactory explanation was forthcoming, until Faraday set the whole theory of electrolysis on a firm basis in his papers communicated to the Royal Society between June, 1833, and March, 1834.

Although many apparent contradictions have been found to Faraday's well known simple laws, and the precise mode in which a current is conveyed through an electrolyte is still under discussion, yet his work showed that chemical and electrical energy were mutually convertible, and that the so-called polarization currents were due to the reversible nature of the chemical changes caused by the passage of the primary current.

The way was thus cleared for improvements in batteries in general, and very many have been brought out; but it was not till much later, when Faraday's other great discovery of the laws relating to the conversion of mechanical into electrical energy bore fruit, and provided a cheap source of electricity, that much attention was paid to reversible batteries.

In the course of his experiments on electrolysis, he nearly anticipated Planté's discovery of the peroxide of lead—lead couple; for in the case of the electrolysis of a solution of acetate of lead, he noticed that on the passage of the current, peroxide of lead was formed on the one plate, and lead on the other.

In 1843, Grove invented his gas battery; and in 1852, Dr. C. W. Siemens constructed a reversible battery, using carbon plates as his electrodes, and a strong solution of acetate of lead as his electrolyte.

In 1859, Planté made a number of experiments with copper, silver, tin, lead, aluminum, iron, zinc, gold, and platinum voltameters, to determine which was the best couple to use for a reversible battery, and decided on the use of lead plates in dilute sulphuric acid, because in discharge both plates were active, that is, not only did the peroxide of lead plate combine with hydrogen, but the reduced metallic lead combined with oxygen; thus the E.M.F. of the cell was due to chemical actions occurring on both plates. In those days the action of the cell was ascribed solely to the decomposition of water, and the effect of the sulphuric acid was left out of account.

In 1872, Planté improved the "formation" of his cell by bringing out the process for alternate reversals of the current, and in the decade which followed, with the improvement of the dynamo, and the consequent growth of electrical engineering, the need for some means of storing electrical energy arose, and the reversible battery passed from the laboratory into commercial use.

REVERSIBLE BATTERIES.

In 1880, M. Camille Faure invented his cell, in which the electrodes consisted of lead plates, smeared with pastes of red lead and litharge respectively, and covered with a protecting layer of felt. On charging, the red lead was oxidized to peroxide of lead, and the litharge was reduced to metallic lead, thus quickly forming a Planté couple of considerable storage capacity.

The same impetus in electrical work which gave rise to the Faure battery led also to the introduction of several other types of reversible batteries, and as I have been able to obtain very little information about them, I will deal with them and their developments now, before proceeding with the numerous improvements in the two lead types.

Professors Thomson and Houston have tried electrodes of copper in sulphate of zinc solution; the plates were laid horizontally, so that the relative weights of the sulphate of zinc and sulphate of copper formed in the working might prevent their mixing too readily. The E.M.F. was the same as that of the Daniell.

M. d'Arsonval modified this battery by making one electrode of lead and the other of zinc, the solution being sulphate of zinc as before. The lead plate forms the positive, and becomes coated with peroxide during charge. According to Miesler, the E.M.F. of this arrangement is 2·13 volts.

Sutton tried copper and lead plates in copper sulphate, the E.M.F. being 1·22 volts.

In 1886, M. Dezmazures brought out a modification of the Lalande and Chaperon cell, the solid copper plate being replaced by a porous one, made by first reducing copper oxide electrically, and then compressing the fine metallic dust so obtained into plates.† The other electrode was made of tinned iron gauze, and the solution was potassium zincate. The E.M.F. is only about 1 volt, but the cells are light, and a battery of this description gave satisfaction, as a source of motive power, at the trials on the French torpedo boat La Gymnote, at Toulon. Recently this battery has been tried for traction work in Philadelphia, under the name of the Waddell-Entz accumulator.‡ In the American form of the battery, the copper plates are made of a sort of a wire rope, formed of a stout wire core, braided over in opposite directions with two layers of wire of different thicknesses, the finest outside. This is again braided with asbestos, or some similar material, which retains and protects the copper oxide formed by electrolysis. The weight of the battery is given as from 55 to 60 lb. per horse power stored.

* A paper recently read before the Society of Arts, London. From the Society's Journal.

† *The Electrician*, vol. xxii., p. 302.

‡ *The Electrical Engineer*, No. 22, vol. vii., p. 556.

LEAD REVERSIBLE BATTERIES.

On the introduction of the Faure cell into England, in 1881, great hopes were entertained of it, and the modification in the manufacture of the plates seems almost to have been regarded as constituting a fresh type of cell, whereas, since the couple was identical, the chemical reactions were the same as in the Planté cell, and any defect due to these would be common to both. As lead reversible batteries cannot be said to have completely realized the hopes then entertained, it is important to discover whether the non-fulfillment is due to causes which can be remedied by improved processes of manufacture, or whether they arise from the chemical reactions occurring in the working of the cell, and are to be met rather by improved treatment after than during construction. I have thought, therefore, that a paper containing a summary of some of the principal improvements which have been introduced in the construction of the cells, and an account of some experiments dealing with the chemistry of the subject, might lead to some useful discussion.

From a comparison of the two cells, made by M. Achard, it appears that on its introduction the internal resistance of the Faure was much higher than that of the former, while the Planté cell took longer to form, and was heavier than the Faure.

The time required for formation, and the weight of the cell, were the chief drawbacks to the Planté process of manufacture; the Faure method had the disadvantage that the applied paste was liable to separate from its support. The remedying of these defects, then, has been the principal aim of the improvements which have been brought out in the two types of the lead reversible battery.* To give a complete list of these would be quite beyond the scope of this paper, but they may be summarized as follows:

I.—IMPROVEMENTS IN THE PLANTÉ TYPE.

By the Planté type is meant that in which the peroxide of lead and spongy lead are formed direct from metallic lead by electrolysis.

In this type, since both the weight of the plate and the time required for "formation" can be shortened by making the plate porous, and thus exposing more surface to the action of the acid and charging current, obtaining porosity has been the chief aim of inventors. The methods which have been suggested from time to time may be classified under three headings:

A. *Chemical.*—The plates are subjected to some "pickling" process, or some special "forming" bath is used.

B. *Mechanical.*—The plates are made of granulated lead, wire, or some form of finely divided lead.

C. *Electrolytic.*—(1) The finely divided lead is obtained by the electrolysis of some salt of lead; (2) some salt of lead is formed into a plate by pressure or otherwise, and then reduced to metallic lead.

Chemical Processes.—Planté found that plates of lead which had been steeped for a long time in dilute sulphuric acid, before being submitted to the action of the charging current, "formed" more rapidly than those which had not been so treated, and he also found that "formation" was hastened by heating the cell during the process; this, however, was difficult in practice.

In 1882, in order to roughen the surface, he pickled the plates, for from twenty-four to twenty-eight hours, in a bath composed of nitric acid diluted with from once to twice its volume of water. The plates were then thoroughly washed, and the formation completed in a bath of dilute sulphuric acid one to ten. By this improvement he stated that a capacity which under the old process took several months to obtain could be acquired in eight days.

Almost simultaneously, Messrs. Elwell and Parker suggested the use of a mixture of nitric and sulphuric acids as a pickling bath. Since then different baths, containing nitric acid in varying proportions, have been brought out, and from the earliest times the addition of some salt of the alkalies, such as ammonium, sodium, potassium, or magnesium sulphate to the electrolyte during formation, has been suggested as an improvement.

In 1884, Mr. FitzGerald proposed the use of phosphoric acid; and in the same year Mr. Tribe experimented with plates partially or wholly converted into sulphide, phosphide, or arsenide, prior to "forming" them by electrolysis.

Coming to recent processes, in 1890 Mr. Epstein suggested first boiling the electrodes in a bath containing

1 per cent. nitric acid;
1 " " potassium permanganate;

or else, in lieu of the permanganate, two per cent. carbonate or sulphate of sodium or one per cent. sulphate of manganese. The plates are dried in air, and then "formed" by the action of the current in an electrolyte containing acetic, phosphoric, or tartaric acid in the proportion of one-half to two per cent.

A few months later, Dr. Paul Schoop brought out his process for first subjecting the plates to the action of a current of about one-sixth of an ampere per 100 sq. cm., at 50 degrees Fahrenheit, in a bath composed either of—

100 parts by weight ammonium sulphate;
140 " " " sulphuric acid (50 degrees);
⅔ds 1 pt. " " potassium chlorate:

or else—

100 parts by weight water;
5 " " " sodium bisulphate;
⅔ds 1 pt. " " potassium chlorate.

* For an account of the lead batteries on their first introduction into commercial work, and of the early suggestions to replace them, see a paper by Prof. W. Grylls Adams, F.R.S., read before the Science Society of King's College, 25th October, 1881, and published in *The Chemical News*, vol. xlv., p. 1. In Mr. Niblett's paper on "Some Recent Improvements in Lead Secondary Batteries," read before the Physical Society of Glasgow University last January, and published in *The Electrical Engineer*, vol. vii., Nos. 13 to 17, will be found an account of the principal structural improvements which have since been effected.

The treatment is continued for from thirty-six to one hundred hours, according to the depth of the active material required. The formation is completed in ordinary dilute sulphuric acid.

Mechanical Processes.—Messrs. Crompton and Howell's well known plates, formed by the compression of a specially porous granulated lead, are an instance of this type, and from their great porosity they are capable of a very high rate of discharge.

In Messrs. Drake and Gorham's cell (Fig. 1), the

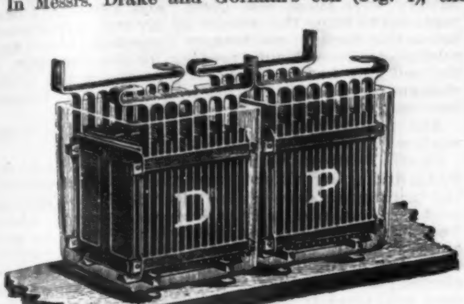


FIG. 1.—MESSRS. DRAKE & GORHAM'S CELL.

plates are formed of roughened strips of lead, laid horizontally one over the other, and connected by their ends to upright rods. From its construction this plate is free to expand and contract without injury to itself.

In Mr. Niblett's so-called "solid cell," * the electrodes are separated by porous partitions, and the space between the electrodes and the partitions is filled up with granulated lead. In this cell there is practically no free electrolyte to wash about and spill; it is all absorbed either in the mass of spongy material forming the electrodes or in the porous partitions.

Plates have also been made of compressed lead dust, of wire loosely woven and compressed, as in Reynier's cell, or in the form of rope, as in the Legay cell.

M. Bandsept's plates would appear to be of this type, as they are made of extremely finely pulverized material, which is then compressed into briquettes and subjected to a forming process. The cell is now in use commercially in Brussels, but very little information can be obtained about it.

ELECTROLYTIC PROCESSES.

1. *The Electrolysis of Some Lead Salt Solution.*—The acetate of lead has been frequently employed for this purpose since Siemens used it; and another salt that has been the subject of many patents is the chloride of lead. In America in 1890, it was proposed by an Englishman, named Currie, to form the electrodes of rods or bars of lead coated with woven asbestos. These electrodes are then placed as anodes in a bath of zinc chloride, and lead chloride to the required depth is formed on them, while zinc is deposited on the cathodes. On reversing the current, spongy metallic lead is produced on what are now the cathodes, and the zinc goes into solution, being thus used over and over again.

2. *The Reduction of a Plate Formed of Some Salt of Lead.*—Perhaps more patents have been taken out under this heading than any other. Plates have been formed of the fused chloride; cerussite, or the native carbonate, has been compressed into plates, and in fact any salt of lead, even lead sulphate, which can be got to reduce to metallic lead by the action of the current, has been employed.

In the Laurent-Cely cell the plates are composed of pastilles of specially prepared lead chloride, round which frames of an alloy of lead and antimony are cast. By the action of zinc in very dilute hydrochloric acid, the plates are converted into cellular lead. The plates are then washed in cold water, dried, and the positives converted into litharge by the action of a current of hot air. The formation is then completed by electrolysis in the usual way.

For this cell it is claimed that the density of the positives is 4·3 to 5, while that of the negatives is only 3 to 3·5. Great storage capacity for weight is also claimed.

II.—IMPROVEMENTS IN THE FAURE TYPE.

By the Faure type is meant that in which the peroxide of lead and spongy lead are formed by electrolysis from some oxide applied to the plates.

As in this class of cell the active material is supplied to the electrodes, and not formed from them as in the original Planté cell, it is obviously desirable that the supporting part of the electrode should be light, and not weakened by taking part in the chemical reactions. These requirements have been met in many instances by replacing the solid lead plate by a grid, usually made of an alloy of lead and antimony, since such an alloy is less acted on by the acid, and is much stronger than pure lead. In the E.P.S. cell the use of an alloy of lead and antimony was abandoned, because, if sufficient antimony to obtain a good casting was added, the grid was so hard that it did not yield to the expansion of the paste, which consequently forced itself out of the plate. Lead grids were then employed, but now they have been abandoned for rapid discharge work, and a solid plate has been reverted to.

In the latest form of Mr. FitzGerald's lithanode cell, weight is reduced by making the support of a light double frame of copper wire, protected from the action of the acid by dipping it first in soldering fluid, and then in molten lead.

The other improvements fall into two principal divisions:

A. Those which have for their object the retention of the paste on the plate, and they may be classed under four headings.

B. Those intended to provide better connection between the support and the active material.

A. The Retention of the Paste.—1. The plate is not perforated, but grooves or recesses are made on the surface; or it is cast with projections from it, so as to afford a lodgment for the active material.

The Tudor plate is a familiar instance of this type, which has the advantage that the support gradually gets "formed," and supplies active material to replace that lost in the working of the cell.

In the new 1890 pattern E.P.S. plate, an early form, introduced by Swan, has been resorted to. The plate is grooved horizontally, as in the Tudor plate, and the ridges between the grooves curve slightly upward toward the surface of the plate, forming a lodgment for the paste.

2. The support is some form of "grid," that is, is perforated with holes, as in the old pattern E.P.S. plate, and the Julien grid (Fig. 2).

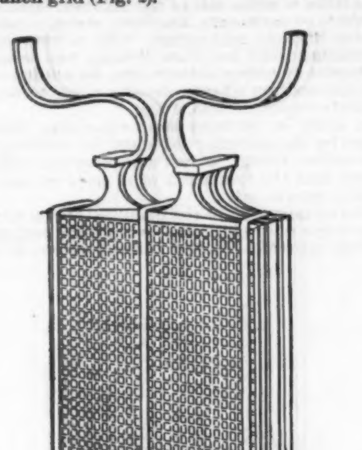


FIG. 2.—ELEMENT CONSOLIDATED EL. STORAGE CO.

A great many varieties of this form of plate have been suggested, and the apertures have been made by casting the grid in a mould, and by punching. Their form has been cylindrical, barrel shaped, as in Messrs. Drake and Gorham's positive plates, shaped like two cones joined at the apexes, and to give greater security the perforation has been made to expand again just at the junction of the apexes.

The construction of a mould, to produce a perforation expanding inwardly, is a matter of difficulty, and therefore the grids are sometimes cast in two halves, and subsequently joined, as in the Gadot cell (Fig. 3).

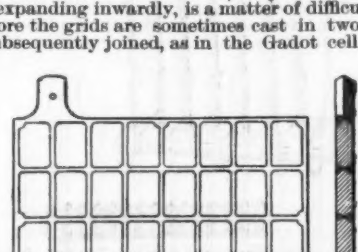


FIG. 3.—PLAN AND SECTION GADOT PLATE.

In the Correns cell (Fig. 4), much used in Germany, the grid takes the form of a double lattice.

FIG. 4.—PLAN OF CORRENS DOUBLE GRID.

3. The active material is inclosed in a perforated conducting retaining vessel.

In this case also the devices resorted to have been very numerous. Plain or corrugated sheets of lead have been taken and folded into boxes, either before or after applying the paste.

In the Roberts cell (Fig. 5) two grids are taken, pasted on one side, and then united to form a plate with the paste inside (Fig. 6).

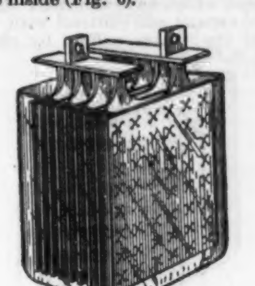


FIG. 5.—"ROBERTS" CELL, COMPLETE.

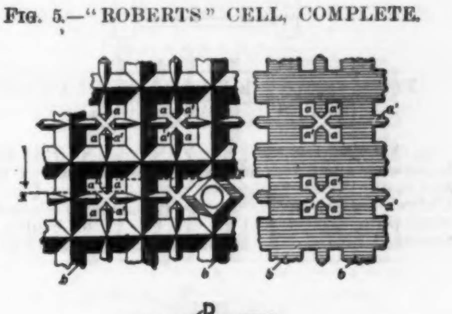


FIG. 6.—"ROBERTS" CELL: DETAIL OF PLATE.

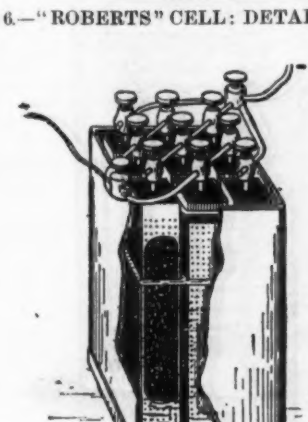


FIG. 7.—TOMASSI CELL, CORNER CUT AWAY TO SHOW INTERNAL ARRANGEMENT.

In Dr. Tomassi's multitubular cell (Fig. 7) the retaining vessel may be constructed of metal, but is usually of some non-conducting material, and so comes under the next heading.

4. The inclosing vessel or plates are made of some non-conducting material, or some inactive material is packed between the plates, to prevent short-circuiting and retain the active material.*

In France the plates have been covered with perforated sheets of celluloid. Reynier brought out what he called an "elastic cell," specially designed for use on torpedo boats. When tried in 1886, on board La Gymnote, it was not a success, and the alkaline copper cell was preferred to it. Since then, however, the construction has been much improved (Fig. 8). Each cell, according to improvements effected in 1889, is composed

FIG. 8.—REYNIER ELEMENT—SIDE VIEW.

* *The Electrical Engineer*, vol. viii., No. 4, p. 80.

* The improvements under this heading are equally applicable to cells of the Planté type; but as they are more frequently applied to cells of the Faure type, I refer to them under this heading.

of one positive, two negative plates, and four porous partitions held together, as shown by a frame consisting of two end plates connected together by corrugated strips of metal, which have sufficient elasticity to enable them to expand and contract with the alteration in volume of the plates caused by charge and discharge (Fig. 9).

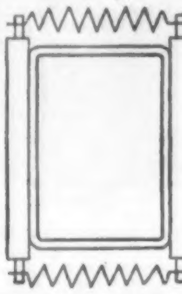


FIG. 9.—REYNIER ELEMENT—PLAN OF COMPRESSING ARRANGEMENT.

In this country Mr. Barber Starkey has tried filling in between the plates with a mixture of plaster of Paris and sawdust; Mr. Fuller uses porous pots; and in the United States, in the Pumpelly battery, cellulose, or wood pulp, is used to separate the plates, which are arranged horizontally, as in the "Atlas" cell (Fig. 10).

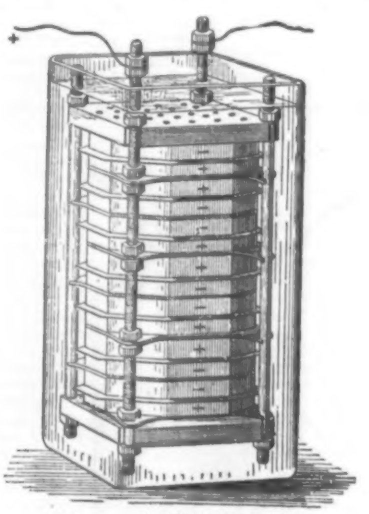


FIG. 10.—"ATLAS" CELL.

B.—Improved Connection between the Applied Oxide and the Support.—With this object the support has been well rubbed with carbon before applying the paste, and the addition of carbon to the paste in some form has been frequently recommended, as, for instance, kneading the oxides into a paste with lead acetate.

In the Tudor cell (Fig. 11) the positive plates are first

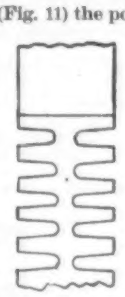


FIG. 11.—TUDOR PLATE—SIDE VIEW, EMPTY.

treated by Planté's process, to coat them with a layer of crystalline electrolytic peroxide; the grooves are then partially filled with a paste of peroxide of lead, and pressure is applied to the ridges to expand them, and partially close the mouths of the grooves (Fig. 12).

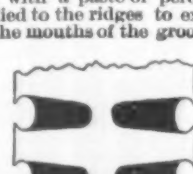


FIG. 12.—TUDOR PLATE—SIDE VIEW, FULL.

The casting or welding of the applied oxide to the plate has also been tried, and, to overcome the difficulty of getting the substances to blend into one another, caused by the great difference in their melting point, it has been suggested to fill the portion of the mould usually occupied by the support with some reducing agent, such as carbon mixed with niter, so that when the fused oxides are poured into the mould they will be reduced in part to metallic lead, which will assume the place and shape of the carbon core, while the remainder forms the active material.

General Improvements.—Besides the improvements in what may be called the manufacture of the plates, or electrodes proper, various devices have been resorted to with the view of diminishing the resistance of the lugs, and securing better contact between plates of the same sign, such as making connection by tinned copper rods passed through holes in the lugs. Lead is afterward cast around the copper, so that it is screened from the action of the acid.

Some attention has also been given to the question of the best electrolyte to use, some advocating the use of acid of density 1,150 to 1,180, while others recommend a density 1,200 and over. The addition of small quantities of some salt of the alkalies, such as sodium sulphate or carbonate, has been recommended by Mr. Barber Starkey and others, with a view of reducing sulphating; and Dr. Paul Schoop has brought out a successful gelatinous electrolyte, by adding one volume of dilute sodium silicate, density 1·180, to two volumes of dilute sulphuric acid, 1·250.

In order to prevent short-circuiting between the plates by the material dislodged in working, they are now either slung, or rest on supports, which are so placed that the formation of a layer of mud between them is prevented.

The equalization of the chemical action over the surface of the plates has also been attempted, and in the Schoop cell (Fig. 13) the current enters at the top of

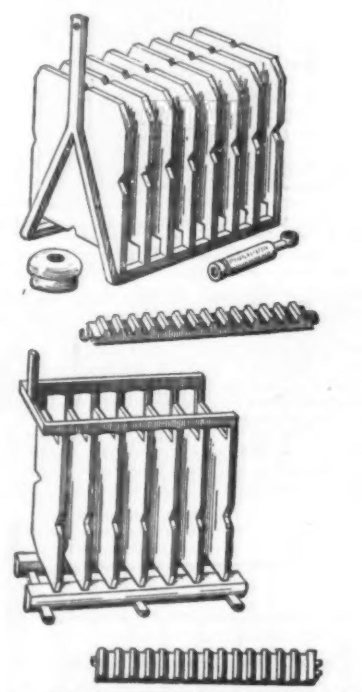


FIG. 13.—PLATES OF "OERLIKON" CELL SEPARATED.

one set of plates, and leaves from the bottom of the others. The plates also are widely spaced now as a rule, the proportion of acid to plates has been increased, and little alterations are constantly being made to secure the free circulation of the electrolyte essential to regular working.

THE CHEMISTRY OF THE ACID.

Although so many different modes of manufacture and preliminary treatment have been resorted to, all the batteries, so far as I am aware, which depend for their action on the couple formed between lead and lead peroxide in dilute sulphuric acid exhibit the characteristic peculiarities noticed by Planté in his cell, namely: The high initial E.M.F. of a freshly charged cell; the fall of E.M.F. on breaking the charging circuit, with corresponding rise on breaking the discharging circuit; the very rapid fall toward the end of discharge which occurs earlier, the more rapid the discharge is, and is not due to the exhaustion of the active material, as after a rest a fresh discharge can be obtained.

As the defects, namely, sulphating and buckling, which have retarded the introduction of reversible lead batteries, are also common to the two types, it appeared possible that they were due to the same causes which produced the variations in E.M.F.; therefore, as the work of Dr. Oliver Lodge* in 1883, and of Miesler† in 1888, had shown that the causes of the variation must be sought either on the lead plate or in the acid next it, and the chemistry of the plate afforded no explanation,‡ I last year, with Dr. Armstrong's advice and assistance, undertook the investigations of the reactions occurring in the acid.

Planté§ had considered that the peculiarities in E.M.F. were due to the formation of peroxides in the acid, and showed that the conditions existing in a cell were favorable to their production, since in voltameters with lead electrodes they were formed in greater quantity than in those with platinum. He also noticed that, immediately on the cessation of the charging current, there was often a small evolution of gas from the peroxide plate; this evolution he ascribed to local action between the peroxide and the subjacent lead.

Commenting on this in their little book, "The Chemistry of Secondary Batteries," Messrs. Gladstone & Tribe point out that the gas is oxygen, and cannot be due to local action, since the gas was evolved whether the peroxide was removed from the supporting plate or not. The application of heat increased the evolution of gas, and the gas was oxygen. Testing the acid between the plates, they always found traces of something which decolorized permanganate, and might, therefore, be hydrogen dioxide or ozone.

* Cantor lecture.

† Monatshefte fur Chemie, viii., 713.

‡ For references and a summary of the principal work done on the cell, see *The Electrician*, vol. xxvii., No. 682, p. 165; No. 692, p. 437.

§ Recherches sur l'Electricité.

Although a very large amount of work has been done on the electrolysis of sulphuric acid solutions, and the general character of the change in the nature of the products formed as the strength of the solution is varied is well understood, the only references I was able to find to any examination of the acid in a battery were those just given; and therefore I have ventured to bring the results of my own experiments before this Society, not because I consider them a final solution of the difficult problem of the chemistry of the cell, but because I hope that the study of the changes occurring in the electrolyte may help to elucidate some points which are at present obscure.

And now it may be as well to refer briefly to the work which has been done in sulphuric acid.

In 1878 Berthelot* discovered persulphuric acid ($H_2S_2O_8$), and brought forward evidence to prove that it is the primary product of the electrolysis of sulphuric acid solutions, and that the hydrogen dioxide—which, from Faraday's time, has been well known to be present in sulphuric acid after electrolysis—is really due to the action of this body on the acid. The products of electrolysis vary with the strength of the acid, 40 per cent. acid (density 1,300) yielding practically no hydrogen dioxide; while below and above that strength it is present in varying proportions. High-current density and an electro-negative condition of the electrodes favor their formation.† Persulphuric acid is an unstable body, and begins to decompose as soon as the current which has given rise to it is stopped, and its decomposition is accompanied by the formation of hydrogen dioxide, unless the sulphuric acid is too dilute. Hydrogen dioxide is also unstable when concentrated, but a weak sulphuric acid solution of it is comparatively stable, and the stability increases the less hydrogen dioxide it contains, therefore this body is found in estimable quantities long after the persulphuric acid which gave rise to it has disappeared.

Persulphuric acid is at once decomposed by spongy metal, such as platinum black, by heat with evolution of oxygen,‡ and resembles hydrogen dioxide in these reactions, and in releasing iodine from potassium iodide, but, unlike it, has no action on permanganate of potassium or peroxide of lead. The effect of electrolyzing a sulphuric acid solution of hydrogen dioxide is simply to increase the rate of the decomposition occurring spontaneously, if a weak E.M.F. is used;§ but on increasing the E.M.F., though the rate of decomposition is increased, a little persulphuric acid is reformed. Subsequent workers have in the main confirmed Berthelot's conclusions. To the oxidizing oxygen in the products of the electrolysis of sulphuric acid, Berthelot gave the name of "active oxygen," and as they pass one into the other, and for most purposes connected with a battery it is not necessary to discriminate between them. I have retained it.

EXPERIMENTS AT THE GENERAL POST OFFICE.

That the nature of the electrolyte affected the behavior of the cell was evident from information received from Mr. Barber Starkey with respect to the effect of the addition of sodium carbonate; and it seemed possible that the different behavior of cells containing this substance was due to its catalytic action on hydrogen dioxide, which is known to be exceedingly unstable in the presence of a trace of alkali; and hence a comparative study of the reactions occurring in cells containing ordinary dilute sulphuric acid, and in those which had been treated on Mr. Barber Starkey's plan, seemed likely to elucidate the causes of the sulphating during rest, and the high initial E.M.F.—the two features most affected by his treatment.

Mr. Preece most kindly aided the investigation by allowing experiments to be carried out at the general Post Office, where one-half of the secondary cells contain 1 per cent. of sodium sulphate, and the other half ordinary dilute acid, density 1,180. He also put at my disposal the records of the behavior of the cells, and they proved that there was much less sulphating with sodium sulphate, as shown by the density of the acid never falling to the same extent as in the plain cells. The following readings taken from short-circuited cells with badly broken plates illustrate this. In two cells containing ordinary dilute acid the density of the electrolyte had fallen to 1,100, while, according to the last readings before the short circuit occurred, it had been 1,170 and 1,180 respectively; while in two sodium sulphate cells the density had only fallen to 1,180 from 1,200 under similar circumstances.

This was strong evidence in favor of the hydrogen dioxide formed in the working of the cell being appreciable in quantity, since if sulphating were only due to local action between the support and the paste, there does not appear any reason why the addition of sodium sulphate should affect it.

Whenever the cells were tested they were always found to contain "active oxygen," which was due to the presence of persulphuric acid and peroxide of hydrogen in varying proportions. During charge persulphuric acid is the main constituent; during discharge the quantity of hydrogen dioxide gradually increases; while in a cell which has been at rest some time there is very little except hydrogen dioxide to be found.

In addition to the tests made on the cells in the electric light and telegraph batteries, I studied the formation of the "active oxygen" during charge and discharge on some cells which were kindly set apart for my special use. The "active oxygen" forms at once on the passage of the current, decreases slightly, and then increases to a little above its first value. Starting either charge or discharge always causes an initial increase, except in the case of cells which have been long idle, when there is a diminution due to the decomposition of the excess of hydrogen dioxide in the acid.

To test whether electrolyzed acid was able to reduce pure peroxide of lead, two equal lots of peroxide were taken by weighing one against the other, and put in two flasks. On to each, 100 c.c. of acid, from next the positive plate of a cell at full charge, was poured, and this caused the evolution of oxygen, which continued

* Berthelot. (*Compt. Rend.* 90, 269-275.)

† Richarz. (*Ann. Phys. Chem.* [2] 31, 912.)

‡ Berthelot. (*Bull. Soc. Chim.* [2], 34, 78-81.)

§ Berthelot. (*Compt. Rend.* 95, 8-11.)

Accumulator.	Type.	Material of Cell. Lead, plates, and H_2SO_4, or otherwise.	Capacity in Ampere Hours.	Capacity in Watt Hours.	Charging Current.	Max. Discharging Current.	No. of Plates.		Thickness of Plates in inches.		Total Area of Plates (sq. ft.)	Amperes per sq. ft. Total plate area. Discharge.	Approximate External Dimensions of Cell.				Total Weight of Cell (lbs.)	Ampere Hours per lb. of Total Weight.	Watt Hours per lb. of Total Weight.	Efficiency (Watt).	By whom Efficiency Test was made.	Remarks.
							+	−	+	−			Length.	Breadth.	Height.	Height over all.						
REYNIER ...	—	Lead and lead peroxide in sulphuric acid.	30	240	—	6 amperes	—	—	—	—	—	—	12-in.	12-in.	—	12-in.	100	0·3	7·4	—	—	These cells are made up in boxes containing 16 couples.
E.P.S. ...	1888 L	Lead grids pasted. H_2SO_4	130	247	10 to 13	13	3	4	—	—	—	—	2½-in.	13½-in.	18¾-in.	20½-in.	74	1·7	3·3	—	—	—
(Electric Power Storage Co.)	1890 K	Ribbed Lead Plates pasted. H_2SO_4	—	—	15 to 25	25	3	4	—	—	—	—	2½-in.	11½-in.	13½-in.	16½-in.	81	—	—	—	—	—
GERLIKON ...	B E F D	Hard lead grid pastes made of red lead and litharge.	30 200 160 70	95 404 304 133	6 30 18 9	10 48 25 9	4 5 5 8	5 6 6 9	0·2 0·2 0·2 0·1	0·2 0·2 0·2 0·1	1·9 8·9 5·6 3·8	5 5·4 4·4 2·3	7·8-in. 9-in. 9·2-in. 5·5-in.	9·2-in. 14·4-in. 11·7-in. 6·8-in.	8·77-in. 16·4-in. 12·5-in. 8·6-in.	— — — —	30·6 136·2 96·8 28·4	1·25 1·6 1·0 2·6	2·4 3·1 3·1 5·0	— — — —	Prof. Kolrausch, Hanovet. Dr. Koppe, Zurich.	— —
"D.P." ...	A	Pasted positives. Lead negatives dilute H_2SO_4	140	265	12	12	—	—	—	—	—	—	13½-in.	8 in.	12½-in.	—	65	2·1	4	—	—	—
(Drake and Gorham)	H		725	1,377	66	66	—	—	—	—	—	—	13½-in.	18-in.	12½-in.	—	240	3	5·7	—	—	—
TOMMASI MULTI-TUBULAR.	—	Red lead and litharge in porus pots. Dilute sulphuric acid.	321	642	25 to 100 amperes.	18 to 30	9 tubes	9 rectangular	0·75-in. by 2-in. by ⅜-in	0⅜ by 2 by ⅜	—	—	6⅜-in.	6⅜-in.	10½-in.	—	Total weight of the electrodes, 47·7 lbs.	Per lb. of electrode, 6·7	—	80 per cent.	—	The weight of the containing vessel is 6·6 lbs., and the volume of the acid is ⅜ gallon, but as the density is not given, the total weight of the cell cannot be calculated.
JULIEN ...	S. 17	Pasted plates...	180	—	15	20	8	9	1-8th	1-8th	5·4	3·6	8-in.	7-in.	10-in.	—	42 lbs.	4·3	—	—	—	The 180 amp. hours capacity is at a discharge rate of 20 amperes.
(Consolidated Electric Storage Co.)		Dilute sulphuric acid	180	—	15	20	8	9	1-8th	1-8th	5·4	3·6	7½-in.	5½-in.	9-in.	—	37½ lbs.	4·8	—	—	—	The electric lighting cells are in glass jars, the traction in covered rubber. Electric lighting and traction.
GADOT ...	1 A	Double grid containing pastelles made from oxides of lead. H_2SO_4	28	51·2	3·1 amperes	52	2	3	—	—	—	—	7-in.	3½-in.	—	13·6-in.	17·6	1·6	3	—	—	—
	10 E		1,163	2,019·7	116	133	11	12	—	—	—	—	21·6-in.	20·4-in.	—	26½-in.	792	1·4	2·66	—	—	—
CROMPTON-HOWELL.	No. 11 17 21 31 61	Lead plates and H_2SO_4	220 340 420 620 1,200	440 680 840 1,240 2,400	28 42 52 78 132	85 135 170 250 500	5 8 10 15 30	6 9 11 16 31			11 17 21 31 61	20 at 3 or 10 at 10	8½-in. 13½-in. 16½-in. 20-in. 54½-in.	12½-in. 12½-in. 12½-in. 12½-in. 12½-in.	12-in. 12-in. 12 in. 12-in. 12-in.	14-in. 14-in. 14-in. 14-in. 14-in.	115 182 220 460 880	1·9 1·9 1·9 1·4 1·4	3·8 3·8 3·8 2·8 2·8	85 per cent. Current efficiency 93 to 95 per cent.	Kennedy-Crompton, engineer, of Kensington and Knightsbridge Company.	For electric lighting, traction, and also electric welding.
ATLAS ... (Société des Applications de l'Electricité)	No. 1	Block composed of plates made of oxides and salts of lead. H_2SO_4.	150	$\left(\frac{2+1\cdot8}{2}\right)150$ 285	8	16 normal 10	10	10	0·4	0·4	—	—	7-in.	6·29-in.	inch. 18·37	inch. 23·75	Weight of plates = 17·63 lbs.; of acid = 6·6 lbs.; of the containing vessel is from 2·2 to 8·8 lbs.	9·6 per lb. of plates. 5·4 to 7 per lb. of total weight.	16·1 per lb. of plates. 8·0 to 10·9 per lb of total weight.	—	—	—
ROBERTS ...	Modified Faure twin plate.	Lead alloy, H_2SO_4 combined with an alkaline solution.	75 150 250 450	162 325 545 990	15 25 35 50	Practically unlimited.	2 4 4 8	3 5 5 9	9-32 9-32 9-32 9-32	9-32 9-32 9-32 9-32	18 9-12 33 9-12 63 9-12 108 9-12	4 4 4 4 (about)	7½-in. 7½-in. 9½-in. 9½-in.	2½-in. 5-in. 5-in. 10-in.	10-in. 10-in. 12-in. 12-in.	12-in. 12-in. 13½-in. 13½-in.	20 38 70 110	3·75 3·95 3·55 4·09	8·01 8·55 7·71 9·00	87 to 93 per cent. according to rate of discharge.	G. M. S. Wilson, Sec. Acc. Company, Toronto. Wm. Roberts, Elec. Acc. Company, Toronto.	The battery is designed for both electric lighting and traction purposes.
LEGAY ...		Plates made of lead wire rope formed by Planté's process.	194	364	20 amperes	200 amperes	4	5	2-3rd	2-3rd	75	—	9-in.	9-in.	9-in.	11½-in.	65	3·07	5·6	—	Laboratory of Société Internationale des Electriciens.	Total weight of plates = 44·1 lbs.
TUDOR ...	VII.—A	Lead	240	456	28	24	—	—	1·3	1·3	—	—	—	—	—	—	112·2	2·2	—	—	—	The plates weigh 112·2 lbs. The weight of the glass containing vessel is 16 lbs., and the cells require 5·5 gallons of dilute sulphuric acid, but as the density of the acid is not given, the total weight cannot be calculated. The mean E.M.F. of discharge is taken at 1·90, and the discharging limit is 1·85.
	D	Lead peroxide in dilute sulphuric acid.	168	321	48	60	—	—	1·3	1·3	—	—	—	—	—	—	112·2	1·5	—	—	—	

slowly for some days. At the end of a fortnight the amount of peroxide of lead in each sample was estimated, and it was found to have decreased from 97·4 per cent. to 93·94 and 94·04 per cent. respectively.

This appears to explain the well known deleterious effect of rest on a cell, for although persulphuric acid itself does not reduce peroxide of lead, it forms hydrogen dioxide on standing, which is capable either of oxidizing the lead plate to litharge or of reducing the peroxide plate to the same substance. In each case the litharge is converted into sulphate by the sulphuric acid.

In an ordinary cell in good order the amount of "active oxygen" is small, varying in quantity from about 0·01 grm. to 0·02 grm. per liter; but this means that in a forty-five pint cell (the size used at the Post Office) there was always sufficient to convert from 3·25 grms. to 7·5 grms. of peroxide of lead into sulphate, or to undo the work of one to two ampere hours charge.

This is not a serious matter if the cells are kept working, as the peroxides are being continually broken up with each reversal of the current, but if the cells stand idle the plates get sulphated, and the amount of "active oxygen" formed in the next passage of the current shows a marked increase.

The figures just given do not represent the total amount of "active oxygen," since the acid absorbed by the plates cannot be tested; but as the acid has more oxidizing power the nearer you get to whichever is the positive plate, except at the commencement of discharge, and the total quantity of "active oxygen" increases rapidly soon after breaking circuit, it seems fair to assume that this increase is due to diffusion from the plates of acid, which has more oxidizing power than that in the body of the cell.

This increase is followed by a decrease which is rapid at first, and then gradually gets very slow, and practically ceases while there is still a fair proportion of "active oxygen" left in the cell.

In the sodium sulphate cells the amount of the oxidizing agent was usually less than in the plain cells; and the amount of hydrogen dioxide was always so, unless the battery had been at rest for some time, when the conditions were occasionally found to be reversed. This, I suppose, is due to the proportion of "active oxygen" in the form of hydrogen dioxide, at the moment of stopping the current, being greater in the plain than in the sodium sulphate cells, while the latter contain more persulphuric acid. In both cells the hydrogen dioxide present at the time of stopping the current will be reduced on the plates, sulphating the surface, and more or less screening them from further action; but as the sodium sulphate cell contains more persulphuric acid, the subsequent formation of hydrogen dioxide will be greater in it than in the plain cell. As far as I could discover, sodium sulphate has little or no action on the acid unless it is added during electrolysis, or to acid which has just been taken from a cell through which a current is passing.

The Pink Color of the Acid.—It has often been noticed that during charge, particularly with new cells, a pink color starts from the peroxide plates, and gradually spreads over toward the lead plates, fading away, however, before reaching them. This pink color was referred to by Mr. Crompton at a meeting of the Institute of Electrical Engineers, on 13th December, 1890, and its origin gave rise to some discussion. So, as the acid in many of the cells at the Post Office was pink, I tested it by concentrating it down, neutralizing with sodium carbonate, and then igniting on platinum foil, and always got the characteristic green of manganese.

However, lest the manganese should have come from some other source than the pink acid, I compared the absorption spectrum of the acid with that of a solution of potassium permanganate of the same shade of pink, and found they both gave the characteristic bands in the green (Fig. 14). I also found that using two strips of platinum as electrodes in a solution of manganous sulphate, or any two strips of lead in dilute acid, gave the same color and the same absorption bands, provided

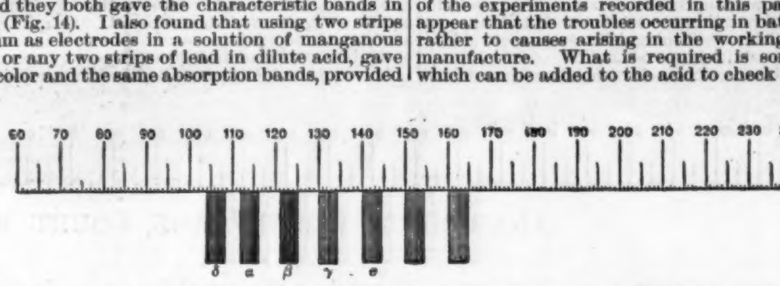


FIG. 14.—ABSORPTION SPECTRUM OF POTASSIUM PERMANGANATE.

the electrodes were sufficiently far apart to prevent reduction by the hydrogen evolved from the negative. This result was important, for it is well known that the pink color disappears from the acid in a short time if it is taken from the cell, and as persulphuric acid has no action on permanganate, but hydrogen dioxide decolorizes it, this disappearance of the color shows that the latter is formed.

The Effect of Hydrogen Dioxide on the E.M.F. of a Cell.—The presence of hydrogen dioxide having been thus proved, both directly and indirectly, its effect on the E.M.F. of the cell was tested. This was done by using strips of lead packed tight into small porous pots, with peroxide of lead to represent the peroxide plates, and using plain strips as the lead plates. A solution of pure sulphuric acid, density 1180, was used as the electrolyte. The E.M.F. of the couple was taken by the deflection method, and then a drop or two of hydrogen dioxide was added to the acid, which produced a great diminution, or even reversal, of the E.M.F.

The effect of introducing hydrogen dioxide into the body of the peroxide paste was also tried, with a view of reproducing, if possible, the conditions of a cell, which is started discharging directly the charge is completed, and in which the "active oxygen" would be accumulated at the positive plate, leaving the lead plate free, and I found that there was a slight increase in E.M.F.

Thus the variations in E.M.F. appear to depend on which plate hydrogen dioxide is formed at. When present at the peroxide plate it causes a rise, but when diffused through the acid and present at the lead plate it causes a lowering of the E.M.F.; and the rise in E.M.F., sometimes noticed on starting the discharge of a cell which has been at rest (mentioned in Professor Ayrton's paper, J.I.E.E., 1890, p. 572), is probably due to the electrolysis and decomposition of hydrogen dioxide, for, in a cell which has been long idle, practically the whole of the "active oxygen" is due to this body.

CONCLUSIONS.

From the same faults appearing in batteries of such different construction, and judging also from the results of the experiments recorded in this paper, it would appear that the troubles occurring in batteries are due rather to causes arising in the working than in the manufacture. What is required is some substance which can be added to the acid to check the formation of the oxidized bodies in it, which cause sulphating, without at the same time injuring the plates in other ways.

Nearly all the "forming" baths which have been introduced are baths in which hydrogen dioxide would be broken up as soon as formed, and, perhaps, in some modification of them the electrolyte of the future will be found; though since the products of the electrolysis of sulphuric acid vary with the strength of the acid and the current density, no hard and fast rule can be laid down for the treatment of cells.

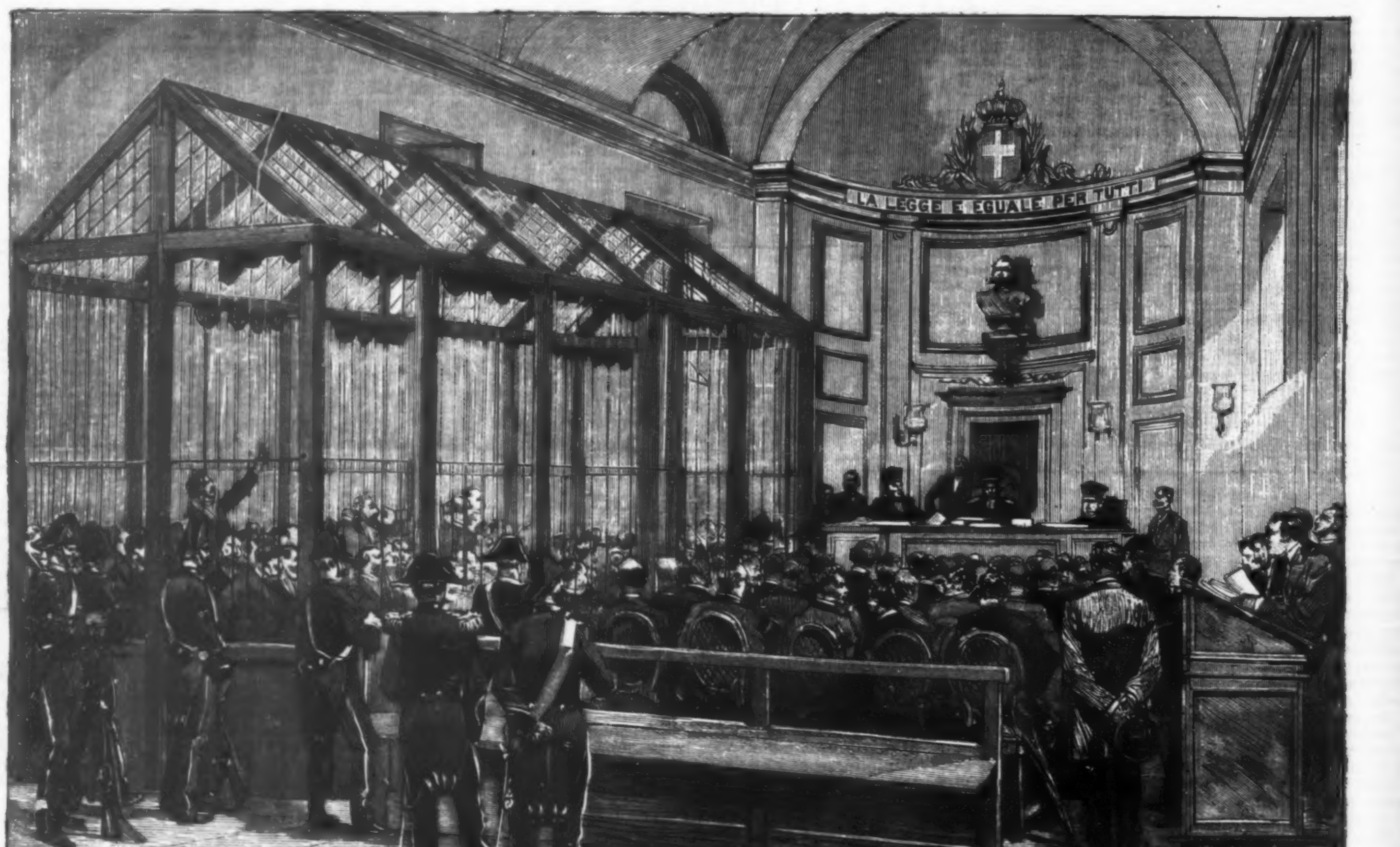
In cells containing acid below density 1,200, in which the proportion of "active oxygen" existing as hydrogen dioxide is high, the addition of one per cent. of sodium sulphate, or similar substance, is likely to prove beneficial, particularly if the work of the cells is intermittent. As the strength of the acid is increased, however, and the conditions are more favorable to the stability of persulphuric acid, less hydrogen dioxide will be produced, and there is more chance of the alkali released from the sodium sulphate during electrolysis damaging the plates.

Also, Dr. Marshall has succeeded in preparing pure persulphuric acid, and has shown this year that it forms salts with the alkalies which are very stable; and what the effect on a cell of the formation of sodium persulphate in it would be, is quite unknown. Although the formation of peroxides in the acid does not apparently account for the great gasing and sudden loss of charge sometimes observed, still we have seen that makers are reverting to Planté's process of manufac-

ture, or modifications of it, and we may find that in this case also he was right, and that it is to the electrolyte we must look if we wish to find the means of materially improving the lead reversible battery.

AN ITALIAN COURT SCENE.

A LARGE number of desperate characters, known as anarchists, were recently arrested and brought up for trial in Rome. It was deemed unsafe by the Italian judges to permit them to have access to the court room in the ordinary manner. A large iron cage was therefore constructed within the judicial chamber, as shown in our engraving, in which the prisoners were made to enter, where they could be freely seen and heard during their pleadings. Our engraving is from *L'Illustration.*



ANARCHISTS' PRISON CAGE, COURT ROOM AT ROME.

THE DIMINUTION OF DRUNKENNESS IN NORWAY.

. . . WHEN lately in Norway, I was struck by two things—the rocky, barren, unproductive nature of the soil and the comfortable appearance of the peasantry. The industry and thrift practiced by both sexes were apparent to the eye; one saw no idlers; all were at work, the men in the fields, the women at the doors of their houses, knitting, sewing and mending garments. One met no men or women in rags, no drunkards, no brawlers, no beggars, and I saw no taverns. On making inquiries I was informed that a great change had lately come over the condition of Norway. Since the legislation of 1866 and 1871, public houses have been practically abolished in the rural districts, and greatly diminished and regulated in the towns. For instance, in Bergen, with a population of 60,000, there are only fourteen licensed houses, all under the strictest regulation. Soon after my arrival I took a drive round the neighboring heights, and was informed that the wonderfully engineered road, the institutions I saw, and the beautiful public gardens through which I passed were all either maintained or aided by the society which enjoyed the monopoly of selling ardent spirits in these fourteen public houses. My curiosity was aroused to know more about this wonderful society, and on making inquiries I was recommended to read a small pamphlet written by Mr. Thomas M. Wilson, C.E., in which he gives a most interesting account of the history and progress of local option in Norway, together with a statement regarding the establishment and working of the society for retailing ardent spirits in Bergen. Mr. Wilson, in the preface to his work, says that he was opposed to the Norwegian system when first introduced, but acknowledges that nearly twenty years' experience of its workings has enabled him to realize how mistaken were his original views, they having been based upon a fear of evils supposed to be attached to the system, which subsequent experience has proved to have been entirely imaginary. He adds that he now realizes fully his earlier mistake, and is perfectly satisfied that the societies for retailing ardent spirits in Norway have effected a maximum of good to the community at large, with a minimum of inconvenience to the legitimate consumer of alcoholic drinks. He states, what is well known, that to the town of Gothenburg, in Sweden, is due the honor of having first attempted to restrain the sale of intoxicating liquors, and that since that time the plan adopted by the municipal council of that city, and subsequently imitated by other urban authorities, has generally been known by the name of the Gothenburg system. In that city the municipal council is the licensing authority, and fixes the number of licenses which it deems necessary for the public convenience. Instead of issuing them to individuals, the council grants a monopoly to a society of shareholders formed for the purpose of acquiring licenses, and which undertakes to conduct the trade in the public interest. The shareholders are precluded by their contract from enjoying a larger benefit than 5 per cent. on the capital invested. All further profit made in the business must be handed over to the municipal council, to be expended by it in the reduction of the public burdens. The monopoly is granted for a limited number of years, and the council retains control over the operations of the society, fixes the number of bars and shops in which intoxicating liquors may be sold, as well as the sites of these establishments, and the appointments of the society's servants are also subject to its approval. The advantage of this system is that neither the society nor the managers of the drinking saloons are interested in the immoderate consumption of ardent spirits—the former being paid a fixed salary, and the latter being precluded from earning a larger dividend than 5 per cent. The disadvantage, on the other hand, according to Mr. Wilson, is that the urban authorities, and the ratepayers generally, are distinctly interested in the multiplication of drinking bars, and in the consumption of alcoholic liquors, inasmuch as all profits over 5 per cent. are paid into the municipal treasury and diminish the weight of public burdens borne by the individual ratepayer. Mr. Wilson tells us that the Norwegians were quick to perceive this blot, and in dealing with the drink question in their own country have adopted the strong and rejected the weak points of the system. In the cities of Norway as well as in Gothenburg the municipal councils fix the number of licenses required to meet the reasonable convenience of the public, and respectively grant a monopoly in each town to a society formed for the purpose of undertaking the trade, usually for a term of five years. The council retains full control over the operations of the society, and its books are open to the inspection of the council. Its statistics, by-laws and regulations, and the appointments in the society's service, are all subject to the approval of the council, and, with the exception of that of the servants, must also obtain the royal sanction and seal. The committee of management is formed of a body of representatives, of whom a certain proportion are now generally elected by the shareholders, while the remainder are appointed by the municipal council, and may or may not be shareholders, or may or may not be municipal councilors. Usually, however, the municipal council appoints members of its own body to act on the committee of management of the society, which, as at Gothenburg, is not permitted to pay a higher dividend than 5 per cent. to its shareholders. Mr. Wilson tells us that the great feature in the Norwegian system, and in which it differs from that of Gothenburg, is the destination of the annual surplus after paying the shareholders their preferential interest. The surplus, instead of going into the local treasury in reduction of the public burdens, is applied each year in making pecuniary grants to the funds of deserving charities, benevolent societies, philanthropic institutions, or other objects of general utility which are entirely dependent for their existence on the voluntary support of the public.—*The Right Hon. The Earl of Meath, in the Nineteenth Century for December.*

MINING VENTURES IN SPANISH AMERICA.

By LOUIS JANIN, Jr.

WHEN their successful revolution had exhausted the Mexicans' capital, and the Spaniards, the former owners, had withdrawn, they were led to offer an opportunity to foreign capitalists to work their mines on joint account on terms highly favorable to the adventurers.

By act of Congress the one-fifth, or, to be exact, the 17 per cent., which had been the king's royalty during the Spanish rule, was reduced to a 5½ per cent. tax on the gross output. Everything else was done to facilitate the successful handling of the properties.

The English, with the spirit of adventure or strong in the Anglo-Saxon blood, were the first to accept this offer. They thought with improved machinery, modern metallurgical methods and the reduction of nearly 12 per cent. in the gross yield, that not only would their product exceed that of the former owners, but their profits would be doubled. Upon this seemingly logical hypothesis as a corner stone, the most fantastic castles were built; promoters overran London, rivaling one another in praise of their properties, and the enormous but certain profits to accrue to fortunate investors drew many a dollar from the confiding public. At last the crash came. Much to their disgust, the victims found their primary hypothesis entirely fallacious; with all their modern advantages they were unable to compete with the former owners.

After the discovery of valuable mines in the United States Americans branched out, and were fated to pass through a foreign experience similar to that of the English in Mexico. In one day's ride in a sparsely populated district of Mexico it is still possible to see seven deserted reduction works, their tall stacks standing monuments to the blind folly of that period.

Since the wild excitement of that time investors have been more cautious. The properties are subjected, in most instances, to a rigorous and critical examination, possibly by several men of high standing; yet it is discouraging to know that failures still occur, and successes are few and far between.

The mining history of all Spanish American countries is similar to that of Mexico. The same causes interfere with success in Central America as do in Bolivia. Without taking up the instance of confessedly worthless properties, since local conditions have nothing to do with their failures, the reasons for failure may be placed under the following general heads: 1. Insufficient working capital. 2. Insufficient mine development. 3. Labor, its cost and inefficiency. 4. Bad management. 5. Poor metallurgy. 6. Inaccessibility.

Insufficient Working Capital.—Too often the estimate for working capital is left to the promoters rather than to the examining engineer. The promoter, for various reasons, does not desire to increase the amount to be raised, so therefore cuts his estimate down to a minimum. The unforeseen always occurs, and there is a deficiency which may react on either the mine or the reduction works. In any event, it is necessary to raise more capital. On the slightest intimation of this necessity the stock falls; the heavier owners, with the proverbial timidity of capital, refuse to send good money after bad, as they term it. Complications arise; the affair drags on for a while until the crash comes, when a set of men leave mining investments never to enter them again.

Insufficient Mine Development.—The Mexican or Spanish system of mining differs radically from ours.

In blocking out ground we lay up capital upon which we can draw; the Spaniard is short sighted and apt to regard as foolish that which brings no immediate return. A large quantity of ore may be in sight, but not in a position for economical extraction. Admitting that the ore is low grade and the margin of profit narrow, so large a force is required to extract the daily tonnage—necessarily large in such a proposition—that the expenses exceed the yield. Unless this is perceived and systematic development followed, although it may be temporarily stayed by a strike of richer ore or other fortunate circumstances, the day of disaster will inevitably come, with the usual consequences.

Labor, Its Cost and Inefficiency.—A man familiar with Western mining wages considers the Spanish American rates ridiculously low, and is apt to promise himself, or others, great economy in working the property. There is no greater fallacy than this. While occasionally in those countries miners can be found comparable to men of any race, it is the exception. Reliance can be placed upon the understanding of the English, Cornish, Welsh, Irish, or, best of all, upon the American miner; if responsibility is placed upon their shoulders, they rise to the occasion. The Spanish races cannot or will not. Their entire work must be laid out for them. A by no means slight loss in a mine with high grade ore is due to their pilfering habits, although the mines are put to much discomfiture by their strict observance of the Sabbath and church festivals.

In certain more remote districts, the difficulty of obtaining laborers, their independence when secured, and their general disinclination to work for an employer's interest is a serious drawback. When, moreover, they are compared with American miners working under similar circumstances in the United States, with the cost of labor per ton of ore produced as a basis of comparison, their inferiority is shown.

If American miners would adapt themselves to those countries—as they do, as a rule, to their worst features—and would work for reasonable compensation, this could be remedied. It must be admitted, however, that the native labor, with all its shortcomings, is the most economical. To a native thoroughly versed in the characteristics of his countrymen, the labor question is a serious one. How much more so is it to an American, who, in nine cases out of ten, has had no previous experience with this class of labor or personal knowledge of their peculiarities, however successful a miner he may have been in the United States?

Bad Management.—By this is meant bad financial management rather than technical errors. In the many transactions of a large business, opportunities for errors of judgment constantly occur; mistakes in letting contracts, in employing subordinates, and mistakes arising from personal prejudice. If the mine foreman, to be successful, has to be familiar with his environments, how much more so has the manager, upon whom rests the responsibility of all departments. Many failures are on record due directly to the manager's unfamiliarity with his surroundings. Others have been caused by his lack of acumen in not securing contiguous ground, and yet others owing to the mental and physical lethargy so many fall into when transferred to a torrid climate.

Poor Metallurgy.—It is possible that bad administration of the metallurgical department has led to a large percentage of the failures. Processes ill suited to the local conditions or to the ore itself have been adopted. One cannot make a careful examination of the *patio* process in Zacatecas or Guanajuato without perceiving how much local conditions have to do with economical metallurgy. In those localities it has been found impossible, after careful experiments, to improve upon the *patio*, either in cost or percentage of extraction.

Inaccessibility.—In the more remote parts of Mexico, Central and South America the cost of freight is a large item in the expense account. When freight from the centers costs from 5 to 15 cents per pound, it is a material disadvantage in working a property. The cost of supplies is doubled. Salt, that most necessary chemical in the milling process, frequently costs, as the locality varies, from 3 to 10 cents per pound. When the ore is subjected to a chloridizing roast, and, of necessity, from 5 per cent. to 15 per cent. of salt is used, the cost of treatment is enormously increased above that of the more favored localities.

The distance and the difficulty of communicating with the central office is another disadvantage of isolation. If lapses and errors occur, it may be months before they can be checked and remedied by those financially interested.

Railroad communications and custom metallurgical works have made Colorado, Utah and Montana successful mining States. As the railroad and the smelter have done away with the necessity of costly reduction works, a mine can now pay from the grass roots. It will be many years before similar conditions prevail in Spanish America. Until that time immediate successes such as have been achieved in the United States can hardly be expected.

To conclude, mining is like no other business; a success this year lessens the chances for years to come. It may be said, therefore, that the statements of ancient production have but little weight in fixing the value of a property in modern times. It has been claimed by the unsuccessful that the governments of those countries are hostile and all titles insecure. This is erroneous. The Spanish mining law admits of fewer complications than our own. The governments, far from being hostile, knowing it is to their own advantage, have done everything to secure success to the investors.—*Engineering and Mining Journal.*

OZONE.

WHEN oxygen contained in a tube is submitted to the discharges of an electric battery or to the action of a current, it is found that the gas has acquired a somewhat peculiar odor and possesses new properties. To oxygen thus transformed, the name of ozone has been given.

A very large number of chemists, Schoenbein being the first, have studied ozone and its characters. It is found in the air, in fact, but in very small proportions. It is due either to incessant electric manifestations in the strata of the atmosphere or to oxidations of multiple sources that take place on the surface of the earth. According as the air is analyzed at different epochs of the year, we find variable proportions of ozone, although they always remain infinitesimal.

Mr. Marie Davy has made numerous quantitative analyses at the Montsouris Observatory, and the results of these, which were very delicate, were as follows: 100 cubic meters of air contain on an average, in milligrammes:

January	2·3	July	1·8
February	3·0	August	1·3
March	2·8	September	—
April	2·0	October	1·4
May	1·5	November	2·0
June	1·3	December	2·4

The production of ozone in the atmosphere is, therefore, greatest in winter. It decreases in spring and reaches a minimum in summer.

The direction of the wind seems to exert an influence upon this proportion of ozone. The north and east winds bring but a small quantity of it. The proportion increases very notably with the south and west winds, and the winds accompanying rain and storms.

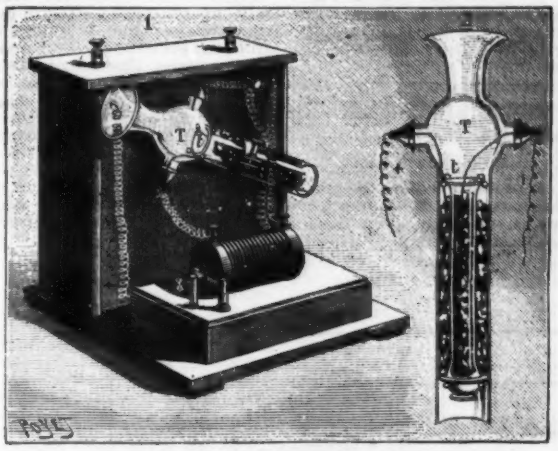
On another hand, ozone is less abundant in the air of cities than in the air collected in the country in the midst of forests, and less in that of plains than in the air taken at high altitudes. This diminution of ozone in large centers is due to the contact of organic substances. The ozone diminishes and disappears, and the presence of this gas at any point is capable of giving data as to the purity of the atmosphere.

Generally speaking, the air contains about 1-700,000 in volume of ozone. In an atmosphere more highly charged with this gas, respiration is effected with difficulty, but beyond certain proportions its influence makes itself felt disagreeably, and it may exert an irritant action. In small quantities it is therefore a stimulant. It is, moreover, a disinfecting agent. In Dujardin Beaumetz's Dictionary of Therapeutics we find the following details as to its therapeutical action:

"Ozonized air is a deodorizer and an antiseptic. It arrests or prevents the putrefaction of vegetable or animal matters and removes all bad odors resulting from the decomposition of organic substances. Provided that it be highly charged with ozone, the air even becomes a powerful bactericide. But it is with this gas as it is with other disinfectants. It is a microbicide only on condition of being so abundant in the atmosphere that the latter would thereupon become a deleterious and irrespirable medium. In a quantity that can be tolerated by the respiratory organs, ozone possesses only disinfectant properties and no longer germicide ones."

It is owing to these stimulating and disinfecting properties that an attempt has been made at various times to apply it to the treatment of diphtheria, pulmonary phthisis, etc. These experiments have been very recently resumed, and ozone, under the form of ozonized air, has been applied to the treatment of a certain number of anæmic and tuberculous cases.

The apparatus devised by Dr. Girerd permits of obtaining, under a very reduced volume, air charged with ozone, and, at the same time, with metallic vapors. Starting from the principle that the quantity of ozone is in direct ratio with the extent of the surface of the electrodes and with the facility with which the electric fluid flows, the inventor employs, to this effect, sheets of beaten metal, such as gold, aluminum, etc. These sheets, loosely packed, thus present a vast surface within a small space.



DR. GIRERD'S OZONE APPARATUS.

The apparatus (Fig. 1) consists of two perfectly cylindrical concentric tubes. The sheets of metal packed in the central tube, *t* (Fig. 2), are put in communication with a conducting wire and constitute one of the poles. The other pole is formed of sheets of metal placed in the annular space between the tubes T and *t*. The system is actuated by a small Ruhmkorff coil giving a 6 mm. spark and supplied by three small sal ammoniac elements. The apparatus is but 20 cm. square, and is thus very portable and practical.—*La Nature.*

ANATOMY AND ART.

MR. OSBORN, F.R.C.S., who is at present delivering a series of lectures upon anatomy in its relation to art to the lady students at Mrs. Jopling's School of Art, London, was able in a recent address, dealing with "The Superficial Muscles," to afford his hearers the unusual advantage of seeing Herr Sandow as a kind and willing "subject" for demonstration. Before introducing the athlete to the young artists, Mr. Osborn explained the nature of the muscular tissue, by means of which the active movements of the body are produced, describing the nerve influences which act upon it to produce contractility, and enlarging upon the difference between the actions of the involuntary and voluntary muscular efforts. As a matter of special importance to realistic artists, Mr. Osborn dealt at some length with the peculiarities of *rigor mortis*, and pointed out the fact that muscular tissue is not wasted

AN OBJECT LESSON IN ANATOMY.

or destroyed by excessive use, but is only increased and developed by exercise.

Sketch books were made ready, and there was a flutter of expectation as Sandow, wrapped in an enormous coat, entered the studio. This he threw off, and at an indication from Mr. Osborn, he stood upon a small table, while the lecturer proceeded to show the position and formation of the principal muscles, explaining how they obtained their surgical names, as biceps, flexors, extensors, or pectoralis major. Meantime, Sandow himself assisted largely in the demonstration by exercising the particular muscles referred to by the doctor, and turning himself about, or assuming the attitudes of severe strain and exertion of both upper and lower extremities. Before resuming his wraps Sandow suggested to Mr. Osborn that the students might be glad to see some of the movements of the voluntary muscles of respiration, and accordingly he showed these under varying conditions up to those of intensest exertion. The lecture and demonstration was followed with the closest interest by the audience, which was composed exclusively of ladies, including a number of hospital nurses from the neighborhood.—*Daily Graphic.*

THE DISPOSAL OF TOWN REFUSE AND OF GARBAGE.

By WOLCOTT C. FOSTER, New York.

ONE of the most difficult problems before the sanitary engineer is perhaps the disposal of the various kinds of refuse produced by towns, especially when the surrounding country is thickly settled. It is proposed in this article to describe an economical method for disposing of and partly using ashes and accompanying matter, or ash bin refuse and garbage.

In the first place it will be found on examining the refuse commonly termed "ashes" that its composition is very complex indeed. Besides the ash from the coal and the cinders it contains, among many other things, pieces of metals of all kinds, tin cans and worn-out household utensils of tin, glass bottles, shells, bones, pieces of rope, twine, carpet bagging, rags, paper, shoes, hats, rubbers, straw, sticks of wood, etc. Now we may consider this as a very complex one, and proceed to treat it as such. For certain reasons, which will appear later, the refuse of cities using hard or anthracite coal can be treated more economically than that from those where soft or bituminous coal is burned.

The carts in which the refuse is collected are emptied into the car shown at A (Figs. 1 and 2). This car, as soon as it is filled, is raised to the upper story (B, Figs. 1 and 2) of the building by the elevator and run in upon tracks to the hopper, C, into which the ashes are dumped. The car is then taken below again to be refilled. From the hopper the ashes pass into the revolving inclined cylindrical screen, D, which is of such a mesh as to retain the tin cans and larger articles and still allow the stuff containing nearly all of the cinders to pass through. The materials retained by the screen pass on through the chute, E, and over the revolving cylinder, F. This cylinder is covered with sheet brass and has a number of very powerful electromagnets within so connected with a commutator that as each eighth of the circumference passes the lowest point in its revolution it becomes demagnetized and remains so until it goes beyond the point, G, when it again becomes magnetic. By this apparatus the iron is separated and falls upon the inclined plane, H, and thence upon the conveyor, I. If any of the pieces of metal happen to become magnetic enough to persistently adhere to the cylinder, they will be detached by G. The iron, consisting mainly of tin cans, is carried by I to the hopper, J, from which it is automatically fed into the revolving furnace, K. Here it is heated to the proper temperature and at the same time strongly agitated, so that any solder which may have been used in joining any parts together is melted and jarred off, falling into the bottom of the cylinder and escaping by the slot, L, into the trough, M. It is led by this trough into a large iron pot, where it is allowed to collect until a sufficient quantity has accumulated. An examination of it is then made and the requisite quantity of tin or lead, as the case may be, added to bring it up to the desired standard, after which it is cast into bars or pigs ready for the market.

The iron passes out of the end of the cylinder and falls upon the counterbalanced door, N. As soon as the weight becomes sufficient, the door opens and the load falls into the pit, O. The door then immediately closes and the operation is repeated. The iron is removed from the pit to be used for making sash weights or any other purpose that may be found desirable.

The balance of the material passing through the chute E is not affected by the magnets, and consequently falls upon the inclined plane P and thence upon the conveyor Q. As the various things are carried along upon the conveyor, everything of value is picked out by boys stationed along the side of it. Each boy has certain classes of material to pick out. The different classes are thrown into the bins R, each class having a separate bin. The substances having no value fall into the bin S.

To return to that part of the ashes which has passed through the screen D. This portion contains essentially all of the cinders, the fine ash, and many smaller stones. It falls upon the conveyor T and is carried to the hopper U, from whence it is fed into the screen V. As the stuff falls into U, it is sprayed with water by the pipe W in order to somewhat prevent the making of so much dust, but mainly to enable the sifting to be done better. It may be well to state here that both the screens D and V are incased in dust-proof boxes, which are not shown on the engraving.

The cylinder V is divided into three parts, each of which is covered by screens of a different mesh. The first or one nearest the hopper is, of course, the finest, and separates out all of the fine ash and cinder. The material passing through this part falls into the bin X and together with that in the bins S, *a* and *g*, may be used for filling in. The second part has a somewhat larger mesh, while the third has a mesh nearly but not quite equal to that of D. The object of these last two sizes is to separate the cinder-bearing material into two parts or grades, for greater convenience in treating with the coal washer or jig to be spoken of later on. The respective portions fall into the bins Y and Z. That material, such as garbage, etc., which has been forced through the screen D by the weight of the superincumbent mass, and of which the greater part is of no value, passes from the end of the screen V into the bin *a*. The coal-bearing matter is taken from the bins Y and Z by the elevator *b*, and carried up and dropped on to the conveyor *c*, by which it is taken to the hopper of the coal washer *d*. Here by aid of water the cinder or partially burned coal is separated from the slate, stones, glass, bones, garbage, and other substances which may accompany it.

The elevator *b* is so arranged that it may be moved along the shafts to which it is attached, so that it will empty the bin Z while the bin Y is filling, and then when the bin Z is empty it is moved along so as to take the material from Y while Z is filling. The coal from the washer goes into the bins *e* and *f*, each size having its own bin, and is then ready for the market. The stones and other waste fall into the bin *g*, while any garbage or light substances go into *h*.

All the bins containing final products have sliding or trap doors so arranged that a wagon may be placed underneath them and loaded by merely opening one of the doors and allowing the contents of the bin to fall into it, thus dispensing with all extra handling.

It is variously calculated that from 30 to 60 per cent. of the mass of the ashes as received would be merchantable. If such is the case, one can readily see that the saving in the cost of transportation alone in removing the ashes from a city like New York would amount to a very handsome sum in a year.

If, now, the rag pickers can be prevented from overhauling the ash barrels, the percentage of available useful material will be greatly increased and likewise so will the profits. In order to accomplish this end and also to keep the streets much cleaner, especially in windy weather, it is proposed to supply the various householders with iron ash barrels of special design, having a cover, which, upon being closed, is fastened by a spring lock. These barrels would be furnished at a very greatly reduced price, on condition that the cover be closed before the barrel is placed upon the sidewalk. The collectors would each have keys with which to unlock the covers, so that the barrels could be emptied into the carts.

The intention is to have disposal stations established at different points in the city, so as to bring the haul within a reasonable distance.

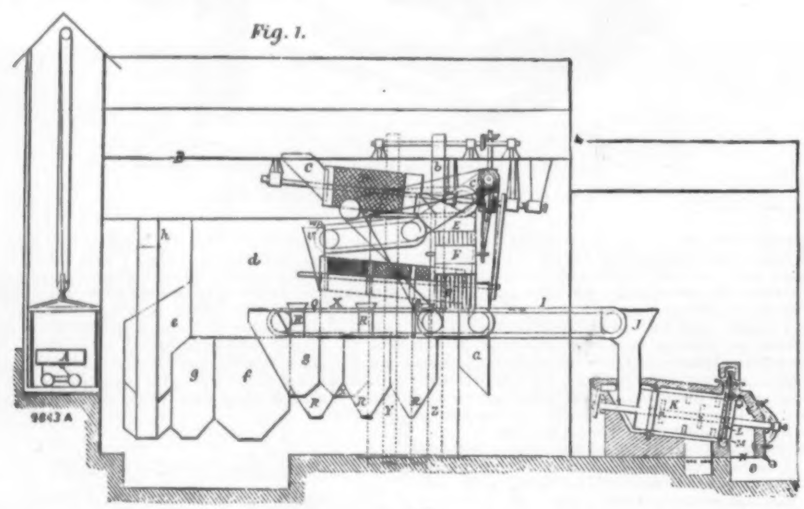


Fig. 1.

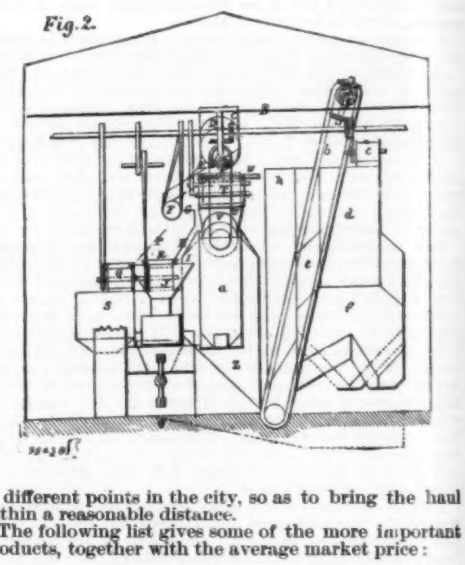


Fig. 2.

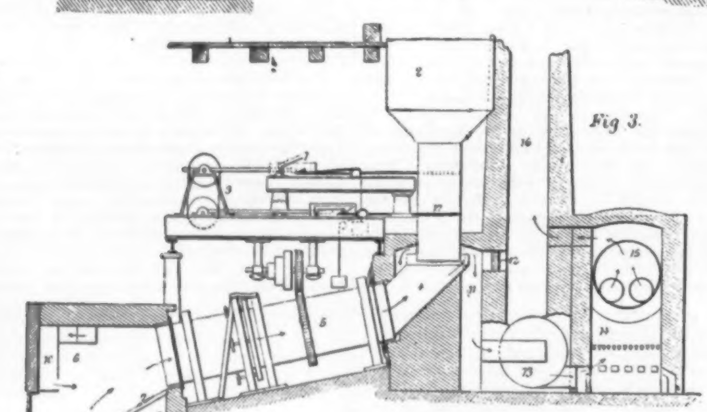


Fig. 3.

The following list gives some of the more important products, together with the average market price:

Substance.	Market Value (U. S.)	Use.
Coal and cinders	$1.50 to $2 per ton.	Fuel to be used for cremat'g garbage. All excess can be sold for domestic use at this price.
Iron	$5 to $12 per ton.	Remelting for sash weights, etc.
Solder	13 c. lb.	Many.
Rags	1 c. to 1¾ c. lb.	Paper stock, oakum, etc.
Paper	¼ c. to ½ c. lb.	
Bagging, rope, twine, etc	1 c. to 3 c. lb.	
Bones, shells, etc	$5 per ton.	For mak'g fertiliz's, etc.
Brass	5 c to 8 c. lb.	Various and many.
Copper	6 c. to 9 c. lb.	
Zinc	3 c. lb.	
Lead	3 c. lb.	
Pewter and other metals and alloys		
Old leather		Several.
Old rubber	1½ c. to 5 c. lb.	
Glass bottles, etc	Various.	Various.
Straw, wood, etc		Used as part of the fuel required in the works.
Stones, fine ash, etc	5 c. cu. yd.	Limited use as a filling material.

In conjunction with the refuse disposal works a garbage cremator would be run. All the extra fuel necessary to accomplish this end being furnished by the wood, straw, coal, etc., from the ashes.

A number of furnaces have been designed with a view to this end, but while some of them accomplish the work admirably, especially on a small scale, the principles used in their construction will not permit of their use where large quantities are to be handled. Others which are calculated to consume larger amounts do not derive as much benefit as they ought, either from the extra fuel employed (where such is necessary) or from the heat generated by the burning refuse. In one class of furnaces, the flames, etc., from the burning coal pass over the top of the moist waste material as it lies on the hearth, thus attempting to set the mass on fire on top and have it burn downward. This method, as the most casual observer can see, is productive of great loss of the calorific power developed both by the coal and by the garbage. Layers of charred matter (charcoal) and ashes soon form over the surface, and as they are both poor conductors of heat, prevent the material below from becoming ignited without an enormous waste of fuel.

With a view to derive as great a benefit as possible from the fuel and burning refuse, especially when dealing with very wet or difficult material, such as night-soil, sewer sludge, green vegetables, etc., and in this way to make the process thoroughly economical, the plant illustrated in Fig. 3 was designed. The principle of construction is the same as that upon which some of the most economical metallurgical furnaces (Bruckner, Howell, Brunton, White, etc.) have been built.

In the first place, the material to be cremated is handled but once, thus reducing the cost of labor to a

minimum. The carts in which the refuse is collected are driven in upon the floor and dumped directly into the hopper 2. From this hopper it is fed automatically at any desired rate by means of the apparatus 3 through the chute into the tube 4. From this tube it passes into the revolving cylinder 5, the speed of which may be varied to suit the needs of the case. Now this cylinder is lined with fire brick and is so arranged on the inside that the refuse is carried around, until the highest or nearly the highest point is reached, when it is dropped across the path of the flames and the heated gases coming from the furnace 6, and from the burning material in the lower end of the cylinder. By these means the refuse is kept finely divided and every particle exposed to the destructive influences.

The moment a coating of charcoal or ashes forms on the surface of any particle, it is immediately broken off by the jar of the falling material, and fresh surfaces thus continually exposed to be acted upon by the heat. The ashes from the cremated substances fall upon the grate, 7, and thence into the pit, 8, from whence they may be removed through the door, 9. Across the upper part of the furnace, 6, pass air ducts, 10. By this arrangement any extra supply of oxygen needed for the complete combustion of the refuse in the cylinder, 5, may be admitted in a very highly heated condition, the quantity being regulated by a proper damper on the outside. Should any of the refuse not be thoroughly consumed, and remain in large lumps or pieces, it will be retained upon the grate, 7, in the direct path of the flames from the furnace until it is completely destroyed.

When the nature of the material is such that little or no extra fuel is required to keep up the combustion, a sheet iron cover can be pushed in from the side over grate, 7, and the speed of the feeding and the cylinder increased to such a rate that all or most of the burning takes place in the furnace, 6, and the cylinder merely used for drying.

At all times it is desirable to adjust things so that when the gases leave the tube, 4, and reach the flue, 11, they will have a temperature as little above 212 deg. Fahr. as possible—say 220 deg. to 240 deg. Fahr.—thus utilizing the calorific power of the fuel and burning refuse to the fullest extent. In case it should become necessary at any time, the damper, 12, may be drawn out, establishing direct communication with the chimney.

The draught throughout all of this part of the apparatus is produced by suction by the blower, 13, thus making it absolutely impossible for any objectionable or dangerous gas to belch out into the building when a door or other aperture is opened.

From the blower, 13, the gases are forced into the ashpit of the furnace, 14, from whence they pass up through the fire, and after imparting their heat to the water in the boiler, 15, they leave the building through the chimney, 16. In the passage of the gases through the fire all obnoxious odors are absolutely destroyed, the products being mainly carbonic acid, carbon monoxide, water, and nitrogen, with traces of a few other substances.

When the fire in 14 is being replenished, a damper closing the communication between the blower and the furnace is shut, and one establishing connection with the chimney opened. Consequently the inward tendency of the air whenever a door is opened in the portion of the apparatus in which the garbage is burning is not even momentarily suspended.

In order to guard against any possible tendency of the upper sliding door of the feeding apparatus 17 to become clogged and refuse to work it is made pronged, *i. e.*, in the shape of a pitch-fork, the garbage above the fork being relied upon to partially seal the opening. However, the leakage of the air into the apparatus at this point is rather beneficial than otherwise, and, in fact, is to be desired to a certain extent, as it furnishes oxygen for the more complete combustion of the gases as well as for the fire in 14.

The amount of material consumed in a day will vary of course with its nature, but a plant having a cylinder 5 ft. in diameter and about 12 ft. long should cremate between 100 and 150 cubic yards every ten hours of average city refuse. The power required to run the cremator is small, being not 10 horse power. The steam for the entire work is furnished by the boiler 15.

All parts of the apparatus are so designed that they shall be readily accessible for repairs, which can be easily and rapidly made, and the plant is so arranged that almost every part can be replaced or repaired without the necessity of removing any other portion. The entire machinery is so simple that it will not break with any load that can be put upon it, while, at the same time, it is not excessively heavy. The various parts as far as possible are also composed of standards obtainable in the open market, requiring neither complicated nor special patterns or templates, so that any moderate machine shop and foundry can furnish all necessary materials. Not only is this the case, but there is also no machine work required, thus reducing the size of the deterioration and repair accounts to a minimum. The number of repairs under the most unfavorable conditions will be so very few as to be of but very little moment.—*Engineering.*

THE TIN PLATE IN SURGERY.

THE intense but somewhat artificial excitement over the tin plate industry which political journals have worked up has, we presume, not much affected the medical mind. We do not care to have it do so; and yet, according to Dr. Elizabeth Reifsnyder, of Shanghai, China, the tin plate meets a long-felt need in medicine, and is destined to be the treatment of the future for ulcers of the leg. As there are over three hundred millions of people in China, and as China, we are told, abounds in leg ulcers, the future of the tin plate industry presents a very stimulating picture to the imagination.

The good news about tin plate did not start from Shanghai, however, but from the equally interesting town of Philadelphia. Dr. E. R. Moras showed its value nearly a year ago, while Dr. Reifsnyder has been trying it on the Chinese for four months.

There are six treatments for ulcers of the leg, according to Dr. Moras: The moist treatment with ointments, washes, etc.; the dry treatment with powders; rest and compression with bandages; skin grafting; transplantation of a flap; the tin plate.

The technique of this last measure is as follows: The surgeon must have bichloride of mercury solution, 1 to 1,000, oiled silk or rubber tissue protective, common sheet tin, adhesive plaster, dressing material, and bandages.

The ulcer and surrounding tissues are cleansed with bichloride solution, then the ulcer is covered with a piece of protective that has been soaked in the same solution. Not only is the ulcer covered, but the protective is cut one third of an inch larger than the ulcer. The tin is a trifle smaller than the protective, so that it does not touch the skin. Tin also has been soaked in the bichloride solution for a few minutes. With one or two strips of adhesive plaster the plate is firmly fastened, a few layers of gauze put over the plate and surrounding tissues, and all held in place by a roller bandage. The plate must be adjusted with uniform pressure.

Impress upon the patient's mind that the plate is not to be removed. The outer dressings have been removed and paper has been substituted for gauze, and the healing process still gone on. Dr. Reifsnyder adds that after giving the tin plate treatment a trial of over four months, "we have found that the ordinary chronic leg ulcer heals in from six weeks to two months. The patients suffer no inconvenience or discomfort while wearing the plate, and in most cases are far more comfortable than they were before its application."—*Medical Record.*

[AMERICAN CHEMICAL JOURNAL.]

RECENT PROGRESS IN INDUSTRIAL CHEMISTRY.

AMMONIA.

Sources.—Practically all the ammonia of commerce, which in the form of sulphate finds extensive use as a fertilizer, is still obtained from the nitrogen of coal. Nearly the whole of that obtained from this source is prepared from the ammoniacal liquor of the gas works, and but little progress has been made in the direction of regaining the immense quantities of ammonia given off in the combustion of coal as fuel.

Most varieties of coal contain 1·3–1·5 per cent. of nitrogen. According to Lunge,* assuming the total quantity of coal burned to be 400 million tons, this would be equivalent, if all the nitrogen could be obtained as ammonia, to 26 million tons of ammonium sulphate, or about 200 times the total amount actually obtained. More than 90 per cent. of this coal is, however, burned as fuel under conditions which make the recovery of the nitrogen as ammonia very difficult. From the portion used in gas making, also, only about one-seventh of the nitrogen contained in the coal is practically obtained in the form of ammonia, the remainder chiefly remaining in the coke or passing off as free nitrogen.

Smaller quantities of ammonia are also obtained from the gases given off from coke ovens and blast furnaces, and in the distillation of shale. The following table, taken from the reports of the English alkali inspector, gives the relative amounts of ammonium sulphate obtained in Great Britain from these various sources within the four years mentioned.

	1886. Tons.	1887. Tons.	1888. Tons.	1889. Tons.
Gas works	82,500	85,000	93,000	100,000
Iron works	4,000	5,000	5,300	6,000
Shale distilling works	18,000	21,000	22,000	21,000
Coke and carbonizing works	2,000	2,700	2,500	3,000

While it appears practically out of the question to save the ammonia yielded when coal is burned directly for heating purposes, there are two methods of using coal as fuel in connection with which immensely increased quantities of ammonia might easily be obtained; these are the manufacture of coke in coke ovens, and the production of gaseous fuel. From these sources we may expect to see in the future the great increase in the world's production of ammonia.

The amount of coal converted into coke, chiefly for metallurgical purposes, is not far from 10 per cent. of the total coal produced. If we assume that the amount so treated is 40 million tons, and that 20 lb. of ammonium sulphate are obtained from one ton of coal, we find that if all the ammonia given off in the coking of coal were regained, not less than 400,000 tons of ammonium sulphate would be obtained from this source. Nearly all the coke produced is, however, made in *beehive* or similar ovens, in which the gaseous products and a portion of the coal are burned in order to carbonize the remainder; with these ovens the saving of the ammonia is impracticable. Flue ovens, in which the coal is coked in closed chambers by the heat of the burning gas circulating through flues in the side walls, like those on the *Coppee* or *Simon-Carves* system, have been introduced to some extent in Europe, and their use is gradually extending. These permit the recovery of the ammonia and tar given off; the chief obstacle to their adoption has, however, been their high first cost. In this country several attempts have been made to use this form of oven and recover the by-products, but these attempts have always been abandoned. Certain forms of flue oven have been greatly cheapened and simplified during the past few years, and have proved very successful and economical in Germany, so that the introduction of this improved process in this country, with production of ammonia as a by-product, is probably only a question of time.

The possibility of obtaining ammonia as a profitable by-product in the conversion of coal into fuel gas in gas producers has lately been demonstrated by the experiments of Mond.† It was found that a good yield of ammonia could only be obtained by keeping the temperature in the producers very low, and by the use of an amount of steam equal to about twice the weight of the coal consumed. Under these circumstances about half the nitrogen is obtained in the form of ammonia, giving a yield of 70 pounds of sulphate per ton, or more than three times the yield commonly obtained in the gas works. Mond's process, which is in operation on a large scale at the soda ash works at Norwich, England, is fully described in the paper to which reference is given. Very complicated apparatus is required for the cooling of the large volume of gas produced, the condensation of the steam, and the absorption of the ammonia by acidified ammonium sulphate

* Thorpe's Dict., "Ammonia."

† *J. Soc. Chem. Ind.* (1889), 505.

solution. The fuel gas obtained contains, by percentage, 15 of carbon dioxide, 10 of carbon monoxide, 23 of hydrogen, 3 of hydrocarbons, and 49 of nitrogen. It is therefore of somewhat lower heating power than ordinary producer gas. According to Mond, its calorific power is equal to 73 per cent. of that of the coal from which it is made. The actual cost of the ammonium sulphate produced, including fuel consumed, labor, etc., is about £5 per ton, or less than half the present price in England. The cost of the plant is very considerable, and it is stated that the process can be successfully worked only by large consumers of cheap fuel. Mr. Mond remarks that if only one-tenth of the fuel consumed in England were treated by this process, that country could supply an amount of sulphate of ammonia equivalent to the whole quantity of that salt and of nitrate of soda used in the Old World for fertilizing purposes.

Fixation of Atmospheric Nitrogen.—Attempts have long been made to bring the nitrogen of the air into combination with carbon or hydrogen and thus obtain cyanides or ammonia. The history of these experiments has lately been fully reviewed by Breneman* and by Fawsitt.† The only methods which have yielded any encouraging results consist in passing nitrogen over white hot charcoal previously saturated with an alkali. A cyanide is thus produced which, if ammonia is desired, may be subsequently decomposed by steam. The process of Possoz and Boisière was carried out in 1843 on a manufacturing scale by Bramwell & Hughes, of Newcastle. Fire-clay retorts were filled with wood charcoal previously impregnated with potassium carbonate; after raising the retorts to a white heat, air was passed through them for a certain time, the contents were then cooled, lixiviated, and the cyanide obtained converted into ferrocyanide by treatment with ferrous sulphate. In this way two tons per week of ferrocyanide were obtained from a bench of eight retorts. From a commercial point of view the process was a failure, owing to loss of potash and wear and tear of the plant; it was therefore abandoned in 1847. A similar process employed by Fawsitt, using sodium carbonate with a view to the production of ammonia, led to equally unsatisfactory pecuniary returns.

Mond‡ has recently made experiments on a manufacturing scale with the process of Marguerite and Sourdeval (Eng. pat., 1860), in which barium carbonate is the alkali employed. This was made into balls with charcoal and pitch; after calcining in a reducing flame the balls were charged into vertical fire-clay retorts heated to a temperature of 1,400° C., and submitted to the action of a current of nitrogen obtained from the carbonating towers of the ammonia-soda process. After a certain time about 40 per cent. of the barium oxide present was converted into cyanide; the briquettes were then dropped into a closed cooling chamber and finally treated with steam, by the action of which ammonia was formed and the carbonate regenerated. Owing to the difficulty of securing fire-clay retorts which would resist the high temperature employed, Mr. Mond was obliged to abandon the experiments; he is, however, of the opinion that the difficulties can be overcome and that the process will prove remunerative for the manufacture of cyanides.

NITRATES.

Until twenty years ago nearly all the saltpeter, or potassium nitrate, of commerce was obtained from India, where it is collected in the form of an incrustation upon the soil in thickly populated regions, arising from the gradual oxidation of animal organic matter. The supply of saltpeter from this source has decreased, and now amounts to about 25,000 tons per year. A large quantity of saltpeter was also made in this country, in the early part of this century, by leaching the earthy matter dug up in caves, chiefly in the Mammoth Cave, Ky.

The deposits of sodium nitrate, or Chili saltpeter, near the seacoast of Chili, in the province of Tarapaca and the desert of Atacama, have lately been fully described in a most interesting report by Consul Walker, of Bogota.§ These deposits have been known and worked for nearly seventy years. They extend a distance of 260 miles along the coast, and have in some places a depth of over six feet. The total amount of available material has been estimated to be 178 million tons. The presence of 20 per cent. of salt and 0·05 per cent. of iodine in the mineral indicates that it has been formed by the gradual oxidation of the nitrogenous matter of seaweed. The "caliche" is refined by recrystallization from water, and comes into commerce 95–98 per cent. pure. The exportation of nitrate of soda from Chili amounted in 1888 to 785,000 tons (of 1,000 kilos), and in 1889 to 921,000 tons. By far the larger part of this product is used in agriculture.

Potassium nitrate is now chiefly obtained by treating the Chili nitrate of soda with potassium chloride from Stassfurt. More than 50,000 tons of the nitrate of soda produced in 1888 was used for this purpose, and Pfeiffer‖ states that 41·2 per cent. of the potassium chloride produced at Stassfurt is employed in this industry. The production of potassium chloride in 1888 was 123,550 tons; 41·2 per cent. of this is 51,000 tons, which would correspond to an annual production of nearly 70,000 tons of artificial saltpeter.

EXPLOSIVES.

The most recent advances in the manufacture of explosive materials have lately been summed up in an interesting manner in papers by Abel¶ and McRoberts.**

All explosive compounds hitherto used for firearms and ordnance have possessed two defects, viz., too rapid combustion, and the evolution of dense volumes of smoke. The efforts of inventors during the past decade have largely been expended in the direction of overcoming these drawbacks.

Gunpowder, which burns with moderate rapidity, produces more smoke than other explosives. Nearly

* *J. Amer. Chem. Soc.*, 11, 1–45.

† *J. Soc. Chem. Ind.* (1890), 30.

‡ Loc. cit.

§ U. S. Consular Reports, No. 114, March, 1890.

‖ *Chem. Industrie* (1888), 129.

¶ Royal Institution Lecture, Jan. 31, 1890.

** *J. Soc. Chem. Ind.* (1890), 476.

50 per cent. of the products of combustion of gunpowder are non-gaseous, and the white smoke produced consists chiefly of potassium carbonate, sulphate and sulphide, in a state of fine division. This large proportion of solid products adds greatly to the corrosion of the bore of the gun. Nobel's experiments have shown that those substances which on explosion liberate the largest proportion of gas and develop the least heat produce the least corrosive effect.

The rapidity of combustion of gunpowder may be to a considerable extent decreased by moulding into larger grains and submitting these to heavy pressure, as is commonly the practice in the manufacture of powder for heavy guns. A further advance in this direction is the introduction of the brown "cocoa-powder," which has lately come into extensive use in Germany. This contains much more saltpeter and less sulphur than ordinary gunpowder; the charcoal it contains is also but slightly burned, and gives the powder a brown shade. This explosive burns more slowly than ordinary powder, and thus produces a gradual and sustained effect upon the projectile. It is said that the smoke produced disappears with extraordinary rapidity, probably owing to the solution of the solid products in the relatively large proportion of water produced, in the form of vapor, on explosion.

Gun-cotton and nitro-glycerine produce little or no smoke when fired. Owing to the difficulty of controlling or retarding the sudden combustion of these substances, however, they have never been successfully adapted for use in firearms, in spite of the large amount of patient experiment which has been expended upon this problem.

The first nearly smokeless powder was probably that introduced by Colonel Schulze, of the Prussian artillery. This consisted of small particles of wood, purified, partially converted into nitro-cellulose, and mixed with potassium chlorate. Within a few years much interest has been aroused by the report that the French government had secured the secret of a perfect smokeless explosive, called the "Vieille powder," or *poudre B*. It is now known that this was a compound of picric acid; it has been supplanted by later discoveries.

The invention of *blasting gelatine*, by Nobel, in 1875, opened the way to the successful application of such powerful explosives as nitro-glycerine and gun-cotton to military purposes. Nitro-glycerine, as is well known, contains an excess of oxygen over that required to completely burn the carbon and hydrogen contained in it, while gun-cotton shows a slight deficiency. Blasting gelatine is a translucent, elastic substance, made by dissolving about eight parts of nitro-cotton in ninety-two parts of nitro-glycerine. The nitro-cotton is a lower degree of nitration of cellulose, similar to collodion cotton. This new explosive is unaffected by water, does not readily explode by percussion, and when detonated explodes with an energy greater than that of either of its constituents. By suitable additions of inert material the rapidity of its explosion may be moderated, and its usefulness for blasting purposes thus greatly increased. This may also be effected by increasing the proportion of nitro-cotton, and in this way a mixture suitable for the ordinary uses of gunpowder may be obtained. The most successful modern "smokeless powders" are of this character.

Nobel's smokeless powder, "balistite," consists of about equal parts of nitro-glycerine and soluble nitro-cotton, with the addition of a small proportion of camphor for the purpose of bringing about the combination of the materials; the effect of the camphor is also to greatly moderate the violence of the explosion. Another smokeless powder, "cordite," invented by Abel and Dewar, is a similar mixture of nitro-glycerine and ordinary gun-cotton, the combination of the two being brought about by the aid of acetone or other solvents; camphor or tannin is added to reduce the rapidity of the explosive action. These powders are similar to blasting gelatine in appearance, and are used in the form of small cubical grains. They are even more gradual in their action than gunpowder, and the rapidity of explosion can be modified to any desired degree by the addition of suitable proportions of camphor, etc. These powders are almost absolutely smokeless, and seem to be capable of successful use in small-arms or cannon. Experiments are now being carried on by several governments with a view to testing the efficiency of the new explosives, and determining the methods by which they can be most safely stored, transported and handled.

SPENCER B. NEWBURY.

DETECTION OF ADULTERATIONS OF BASIC SLAGS.

By DR. MORGAN.

IN the Agricultural Section of the German Congress of Naturalists and Physicians the author pointed out various methods for the qualitative detection of adulterations in basic slag. The loss on ignition is important. If the sample is genuine, there is no loss. If it amounts to ½ to 1 per cent., the sample is almost always adulterated. The determination of the specific gravity also gives a clew, especially in the case of sophistication with Redonda phosphate. The author does not use for this determination a solution of mercuric potassium iodide, but bromoform (specific gravity = 2·9).

Treatment with dilute soda lye separates Redonda phosphate and basic slag. If there is an impurity of Redonda phosphate, a very copious precipitate is produced.

If the coarsely ground sample is examined, yellow particles are found if Redonda phosphate is present, but not in case of a pure basic slag.

The best method for a quantitative determination is that of Jantsch and Schucht. The P_2O_5 of basic slag is perfectly soluble in 5 per cent. citric acid, but not that of Redonda phosphate.

"Taffin" slag behaves like basic slag, but it remains suspended in bromoform. Dr. Loges, of Posen, mentioned a new spurious material said to be of English origin. The small sample which he had obtained contained 4 per cent. caustic lime, 6·4 per cent. calcium carbonate, as well as calcium fluoride. It is probably sophisticated with Welsh phosphate.—*Chemiker Zeitung; Chem. News.*

STEAM HEAT ON PERMANENT MAGNETS.

THE influence of steam on magnets is the subject of an interesting note in the *Schweizerische Bauzeitung*, in which reference is made to the researches of Strouhal and Barus. These have shown that with long-continued heating in steam, magnets lose from 28 to 67 per cent. of their power. If, after this, the magnets are remagnetized and again exposed to the action of steam, only a very slight loss of magnetic power is found to take place. The experiments which have been made would seem to warrant the conclusion also that after such treatment a magnet is less liable to deterioration from mechanical vibration as well as heat. In one of the experiments, a short magnet was boiled in water for four hours. It was then magnetized and held in an atmosphere of steam for two hours more, after which its magnetic moment was measured. It was then subjected to fifty blows from a piece of wood, both transversely and longitudinally. Again measuring its magnetic moment, showed a loss of $\frac{1}{170}$, and on repeating the hammering with the wooden bar the loss was $\frac{1}{160}$ of the original moment. In view of all this, repeated steaming and magnetizing is recommended as a good means of securing permanent magnetism in pieces of hard steel.

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